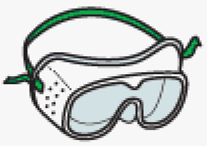
5. General Science Laboratory Safety Specifications



General science or interdisciplinary science broadly focuses on scientific research, knowledge and inquiry. It is the holistic approach to basic science literacy. In Connecticut schools, science curriculum and assessment (Connecticut Academic Performance Test or CAPT in Grades 9 and 10) work toward achieving this goal by exposing students to a myriad of science experiences and study. Hands-on, process and inquiry techniques are encouraged through laboratory and field work. To provide exciting and safe science experiences for students, the following safety specifications and prudent practices are highly recommended and in most cases required by regulatory agencies (OSHA, NFPA, ICC, etc.).

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A. Environmental Settings and Considerations

1. Laboratory Footprint

   The science work areas are the first line of defense for safety by design. They include the laboratory, preparation room and storeroom.

   Footprint safety hints:

   a. There should be separate rooms for laboratory activities, preparation rooms and storerooms.

   b. Furniture placement in laboratories should be designed in such a way as to facilitate easy movement, fast egress, direct observation/supervision and no trip/fall hazards.

   c. Rooms should have two exits if more than 1,000 square feet (92.9 square meters).

   d. Legal occupancy loads per National Fire Protection Association (NFPA) and International Code Council (ICC) should be addressed based on 5.0 square feet (4.6 square meters) net per occupant in a lab. Quasi-legal or academic/professional best practices state that science classes/labs should have no more than 24 students even if the occupancy load limit might accommodate more (NSTA 2004). Research shows that accidents rise dramatically as class enrollments exceed this level (West 2001). This is providing the legal occupancy load is not violated.

resistant material with a front lip approximately 0.75-inch (1.9 centimeters) high.

c. Chemicals should not be stored alphabetically. For example, acetic acid and acetlehyde (acetaldehyde) could be adjacent neighbors on a shelf and are an incompatible pair.

d. Flammable liquids should be stored in flammable liquid storage cabinets.

e. Flammable and combustible cabinets should not be directly vented. Venting of these cabinets is not recommended or required except for odor control of malodorous materials. The openings on the bottom and top of the cabinets should be sealed with bungs supplied with the cabinet. If the cabinets are to be vented, vent from the bottom openings and makeup air from the top openings (NFPA 30, 4-3.2).

f. Corrosive chemicals such as acids and bases should be stored in separate appropriate chemical storage cabinets. Store corrosive liquids and solids in separate cabinets.

g. Nitric acid should be stored separately from acetic acid in a separate cabinet.

h. Lithium, potassium and sodium metals should be stored under dry mineral oil.

i. All peroxide-forming chemicals (e.g., ethyl ether) should be monitored for age and removed after recommended shelf life.

j. Heavy items should be stored on lower shelves.

k. Never store chemical containers on the floor.

l. Chemical storage areas should be kept dry and in a temperature range of 50-80 degrees Fahrenheit.

m. Chemical storage should be stored by a compatibility and use system, in addition to being secured behind locked doors and cabinets.

n. Chemicals can be separated into organic and inorganic families, and then into compatible and related groups. Compatible groups can be separated by use of different shelves. Only store chemicals alphabetically within a related and compatible group.

Examples of storage groups that are related and compatible:

1. Inorganic Family
    a. Metals, hydrides
    b. Halides, sulfates, sulfites, thiosulfates, phosphates, halogens
    c. Amides, nitrates (except ammonium nitrate), nitrites, azides
    d. Hydroxides, oxides, silicates, carbonates, carbon

e. Sulfides, selenides, phosphides, carbides, nitrides
f. Chlorates, chlorites, perchlorates, perchloric acid, chlorites, hypochlorites,peroxides, hydrogen peroxide
g. Arsenates, cyanides, cyanates
h. Borates, chromates, manganates, permanganates
i. Other inorganic acids (except nitric acid)
j. Sulfur, phosphate, arsenic, phosphorus pentoxide

2. Organic Family
    a. Acids, anhydrides, peracids
    b. Alcohols, glycols, amines, amides, imines, imides
    c. Hydrocarbons, esters, aldehydes
    d. Ethers, ketones, ketenes, halogenated hydrocarbon, ethylene oxide
    e. Epoxy compounds, isocyanates
    f. Peroxides, hydroperoxides, azides
    g. Sulfides, polysulfides, sulfoxides, nitrites
    h. Phenols, cresols

Note: Suggested storage groups are listed as a model only. Usage of certain hazardous chemicals at the high school level is not encouraged, e.g., isocyanates, arsenates, cyanides, cyanates and others.

7. Clothing/Hair:

Do not wear loose/baggy clothing or dangling jewelry. They are a safety hazard in the laboratory. Make sure long hair is tied back behind the ears. Acrylic nails are flammable and should not be exposed in the laboratory.

8. Cold/Heat Protection:

When dealing with cryogenic or very hot materials, use heat-safety items such as safety tongs, mittens, aprons and rubber gloves.

9. De-energizing Equipment:

De-energize all equipment when leaving the laboratory. Examples include unplugging equipment (like microscopes), shutting off gas valves (use the master gas shutoff), and shutting off all water faucets.

10. Evacuation Drills:

Establish, provide signage and practice laboratory evacuation drills based on NFPA and OSHA regulations in case of fire or other incidents. Gas and electricity should be shut off during evacuations.

Keep all exits and safety equipment free from obstructions in any way. No materials should be stored in the corridors.

environmental certification program approved by the Department of Administrative Services, in consultation with the Commissioner of Environmental Protection. Such cleaning product shall, to the maximum extent possible, minimize the potential harmful impact on human health and the environment. (c) On or before April 1, 2010, the Department of Education, in consultation with the Department of Public Health, shall amend the school facility survey form to include questions regarding the phase-in of green cleaning programs at schools. (d) On or before October 1, 2010, and annually thereafter, each local and regional board of education shall provide the staff of each school and, upon request, the parents and guardians of each child enrolled in each school with a written statement of the school district's green cleaning program. Such notice shall include (1) the types and names of environmentally preferable cleaning products being applied in schools, (2) the location of the application of such cleaning products in the school buildings and facilities, (3) the schedule of when such cleaning products are applied in the school buildings and facilities, (4) the statement, "No parent, guardian, teacher or staff member may bring into the school facility any consumer product which is intended to clean, deodorize, sanitize or disinfect.", and (5) the name of the school administrator, or a designee, who may be contacted for further information. Such notice shall be provided to the parents or guardians of any child who transfers to a school during the school year and to staff hired during the school year. Each local or regional board of education shall make such notice, as well as the report submitted to the Department of Education pursuant to subsection (a) of section 10-220.

This includes glass cleaners, hand cleaners, general purpose cleaners and more. Green cleaners contain no fragrances, have low volatile organic compounds or VOCs, perform well and have minimum health effects.

Science labs are havens for biologicals (mold, mildew, bacteria, animal dander, etc.) and physicals (particulates, chemical vapors, etc.). In the spirit of the statute, high school science teachers need to work with custodians in effort to transition into the use of greener cleaning products. From the science curriculum side, improved choices need to be made relative to safer alternatives to hazardous laboratory chemicals and also adopting the microchemistry approach.

The Green Schools Initiative and the Green Purchasing Institute recommend the following approach (Green Schools.Net – Best Practices for Disinfection):

Clean first: Disinfectants and sanitizers don't penetrate the dirt/microbe barrier effectively. Before applying disinfectants or sanitizers, surfaces should be thoroughly cleaned with soap and water or other green cleaner if possible.

Determine where and when disinfectants are needed: Use low-level disinfectants on surfaces in the lab that hands directly touch – benches, sinks, faucets, etc. If there is an incident resulting in blood or other potentially infectious materials (OPIMs), a high-level disinfectant should be used.

Dispose of all chemical waste properly as noted by the teacher or MSDS. Chemicals should never be mixed in sink drains. Sinks should only be used for water and those solutions noted by the instructor. Solid chemicals, filter paper, matches and all other insoluble materials are to be disposed of in the properly labeled waste containers. Cracked or broken glass should be placed in the special container for "Broken Glass."

Waste disposal or items to be recycled should be done on an annual basis. There needs to be appropriate storage and labeling.

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C. Personal Protective Equipment (PPE) Requirements:

1. Eye Protective Devices

   Eye protection is required by Connecticut state statute where the process used can cause damage to the eyes or where the protective device can reduce the risk to injury. For example, students in a ninth-grade science class using meter sticks for measurement gathering or launching rockets should have safety glasses with side guards at a minimum. If hazardous chemicals such as acids are being used, chemical splash goggles are required. The general guide is as follows:

   Chemical Splash Goggle (indirect vents and ANSI impact standard Z87.1) when using hazardous liquids or solids.

   Safety glasses (side shields and ANSI impact standard Z87.1) when using solids or projectiles.

   Eye protection should be hygienically cleaned after each use via UV goggle sanitizer, alcohol wipes or detergent and warm water.

   All K-12 schools in Connecticut are required to have the State Goggle Statute Section 10-21 4a-1, (including chart and precautions) posted in science laboratories. The signage must be in clear view for occupants to see.

Regulations Concerning Eye Protective Devices As Authorized by Section 10-21a of the Connecticut General Statutes

The regulations of Connecticut state agencies are amended by adding sections 10-21 4a-1 to 10-21 4a-3, inclusive as follows:

Section 10-21 4a-1. By whom, when and where eye protective devices shall be worn: definitions. Any person who is working, teaching, observing, supervising, assisting in or engaging in any work, activity or study in a public or private elementary or secondary school laboratory or workshop where the process used tends to damage the eyes or where protective devices can reduce the risk of injury to the eyes concomitant with such activity shall wear an eye protective device of industrial quality in the manner in which such device was intended to be worn. For the purposes of sections 10-21 4a-1 to 10-21 4a-3, inclusive, "workshop" and "laboratory" shall include any room or area used to teach or practice industrial arts, vocational and technical education; science, arts and crafts, or any similar skill, activity or subject. The following list of sources of danger to the eyes and the type of protection required to be worn in each case is exemplary, not exclusive.

Source of Danger to the Eyes	Type of Protection Required
a) Caustic or explosive chemicals	Clear goggles, splash proof
b) Explosives, solids or gases	Clear goggles
c) Dust producing operations	Clear goggles, splash proof
d) Electric arc welding	Welding helmet
e) Oxy-acetylene welding	Colored goggles or welding helmet
f) Hot liquids and gases	Clear goggles, splash proof
g) Hot solids	Clear or colored goggles, or spectacles
h) Molten metals	Clear or colored goggles
i) Heat treatment or tempering of metals	Clear or colored goggles
j) Glare operations	Colored spectacles or goggles, or welding helmet
k) Shaping of solid materials; chipping, cutting, grinding, milling, sawing, stamping	Clear goggles or spectacles
l) Repairing or servicing of vehicles when hazard is foreseeable	Clear goggles or spectacles
m) Spraying and dusting	Clear goggles, splash proof

n) Other similar activity being conducted in the instructional program which risks damage to the eyes	Proper eye protective device

Section 10-21 4a-2. Minimum standards for the design, construction and quality of eye protective devices used in schools. Any eye protective device used in such school workshops or laboratories shall be designed and constructed to resist impact, provide protection against the particular hazard for which it is intended, fit snugly without interfering with the movements of the user and be durable, cleanable, and capable of frequent disinfection by the method prescribed for such device by the school medical adviser.

All materials used in such eye protective devices shall be mechanically strong and lightweight, non-irritating to perspiring skin and capable of withstanding washing in detergents and warm water, rinsing to remove all traces of detergent and disinfection by methods prescribed by the school medical adviser without visible deterioration or discoloration. Metals used in such devices shall be inherently corrosion resistant. Plastics so used shall be non-flammable and shall not absorb more than five percent of their weight in water.

Section 10-21 4a-3. Responsibilities of public and private elementary and secondary school governing bodies. The governing board or body of each public and private elementary and secondary school in the state shall require the use of appropriate eye protective devices in each laboratory and workshop by any person in such areas during any activity engaged in, and shall post warnings and instructions in laboratories and workshops which include the list of hazards and protection required set form in Section 10-21 4a-1. Such boards shall make and enforce rules for the maintenance of all eye protective devices in clean, safe condition and shall replace any such protector which becomes irritating to the skin.

Purpose: To direct the school administrators in the kinds, construction, times and uses of devices for eye protection of teachers and pupils in school laboratories and workshops.

Connecticut Law Journal, January 9, 1968

2. Face Protection

Eye protection leaves the face exposed. In certain instances, additional PPE is required beyond eye protection. Face shields protect against most splashes of severely corrosive materials and flying particles. A better solution is to use a fume hood with the sash down as a face barrier.

3. Hand Protection

   OSHA Hazard Communications and Laboratory Standard required PPE for hands. Gloves are designed for very specific types of situations. One type of glove does not fit all needs. The manufacturer's claims should be reviewed and followed. Gloves should only be used under the conditions for which they were designed.

   Types of gloves appropriate for secondary schools include:

   a. Latex/vinyl (microorganisms and biological material – latex is a known allergen for some people and therefore should be avoided);
   b. Butyl rubber (most acids);
   c. Cotton (absorbs perspiration);
   d. Asbestos (heat - caution - asbestos is a known carcinogen!);
   e. Polyvinyl alcohol (organic compounds);
   f. Nitrile rubber (insulates against electricity);
   g. Neoprene (solvents).

   Check Material Safety Data Sheets for the appropriate type of glove for maximum protection.

   Glove removal is effected by peeling one off of your hand starting at the wrist, moving toward the fingers. Don't allow the surface of the exposed glove to come in contact with the skin. When one glove is removed, use it to peel off the remaining glove.

4. Foot Protection

   For laboratory work, students should be wearing closed toed shoes or sneakers. No flip flops or sandals are allowed. This protects the feet from falling objects such as spilled chemicals, weights, rocks, etc.

5. Aprons

   Aprons are required to protect clothing and skin from spills, splashes, etc. On absorbent type aprons are the best. Make sure they are the appropriate length - just below the knees to prevent trip/fall hazards if too long.

6. Clothing

   The greatest protection is from long pants and long sleeve shirts/blouses. This again protects the skin.

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Resources

American Chemical Society

American National Standards Institute

Centers for Disease Control

MSDS Online

National Academy Press

National Fire Protection Association

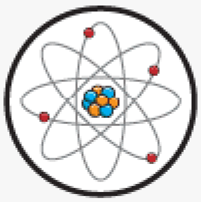
National Safety Council

National Science Education Leadership Association

National Science Teachers Association

Occupational Health and Safety Administration

6. Physics Laboratory Safety Specifications



A. Electricity

Given the inherent dangers in the laboratory study of electricity, safeguards and safety procedures need to be in place for students and teachers. Consider the following safety specifications in working with electricity:

1. Know where the master switch is for electricity in the laboratory in case of an emergency.
2. Make students aware of the appropriate use of electricity and dangers of misuse and abuse.
3. When using batteries, always inspect them first for cracks, leaking, etc. Discard in an environmentally appropriate way if any of these conditions occur.
4. When unplugging cords, always pull cords from the plug at the electrical receptacle and never pull the cords from the wire.
5. Use only ground fault interrupt circuits (GFI) protected circuits!
6. Remove all conductive or metallic jewelry before working with electricity.
7. Prevent trip and fall hazards by placing wires away from places where people walk.
8. For routine maintenance like changing bulbs, make sure the device is unplugged before initiating the work.
9. Review OSHA's lockout/tagout standard (29CFR 1910.147 and 1910.333) prior to working on any electrical device.
10. Never open a battery. The contents are corrosive and can be toxic or poisonous.
11. When storing batteries, never allow the terminals to touch or short circuit.
12. Be water phobic when working around electricity. Never use water or have wet hands when dealing with cords, plugs or electrical equipment. Never run a cord near or over a sink.
13. Utility pipes such as water and gas are grounded. Do not touch an electrical circuit and utility pipes at the same time.

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14. Never plug damaged electrical equipment into a wall receptacle. This includes frayed wires, missing ground pin and bent plugs.
15. Never overload circuits as they will overheat and cause power outages or fires.

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B. Electrostatic Generators:

Electrostatic generators such as Van de Graaff generators are a real attention getter for students in the study of electrostatics. The following prudent safety procedures are in order, however:

1. The generator should only be operated by and under the direction of the teacher.
2. Electronic circuit or devices such as cell phones, computers and cameras can be permanently damaged by the machine's sparks. Keep them at least 50 feet (12 meters) away.
3. Always use a surge protector inline with the generator's power cord.
4. Students with epilepsy, heart or nervous system conditions, or pacemakers should never operate or be in the proximity of an electrostatic generator.
5. Never operate the generator near flammable or combustible materials.
6. Never leave the machine operating unattended.

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C. Ionizing Radiation:

Although the use of ionizing radiation sources in high school science laboratories is not advocated, some physics courses do, in fact, provide these kinds of laboratory activities. When considering having students work with ionizing radiation at the high school level, it is necessary to have planned safety protocols in place. The following safety procedures should be reviewed and adopted prior to dealing with radioactive materials:

1. Select only low-level alpha and beta emitters.
2. To prevent accidental entry of radioactive materials into the body, high standards of cleanliness and good housekeeping must be maintained in all laboratories where radioactive materials are present and/or used.
3. Visitors are not allowed without approval of chemical hygiene officer or school system safety compliance officer.
4. Table and bench tops should be of a nonporous, chemical resistant material. Working surfaces shall be covered with absorbent paper regardless of the type of surface.
5. Eating or drinking in laboratories that deal with radioactive materials is

unsafe and forbidden. Refrigerators will not be used jointly for foods and radioactive materials.

6. One or more trial runs beforehand with nonradioactive materials are recommended for new procedures and new personnel to test effectiveness of procedures and equipment.
7. Do not work with radioactive materials if there is a break in the skin below the wrist.
8. Always use gloves when handling more than a few hundred counts per minute. Wear protective clothing (lab coats, masks, shoe covers) as needed.
9. When work is completed each person will clean up his own work area and arrange for disposal or proper storage of all radioactive materials and equipment.
10. Wash hands and arms thoroughly before handling any object that goes to the mouth, nose or eyes (e.g., cosmetics, foods). Keep fingernails short and clean.
11. Laboratories shall provide special radioactive waste containers. These shall bear the words “Caution, Radioactive Waste” and a warning to janitors against handling.

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D. Mechanics:

The study of mechanics in physics provides many touchstones to everyday applications. However, laboratory activities in this area are not without danger. Students and teachers can be injured if hit by rapidly moving objects or projectiles.

Always use caution when dealing with projectiles, falling objects, moving equipment, exposed belts, powerful permanent magnets, sharps such as Exacto knives and razor blades, and springs.

Special attention should be given to the following safety procedures when working with model rockets.

Use only lightweight, nonmetal parts for the nose, body and fins of the rocket.

1. Use only commercially made model rocket engines.
2. To prevent accidental eye injury, place launchers so that the end of the launch rod is above eye level or cap the end of the rod when it is not in use.
3. Always use either safety glasses or safety goggles with an ANSI Z-1 rating when launching rockets.
4. Do not tamper with rocket engines or use them for any purposes except those recommended by the manufacturer.
5. Launch rockets outdoors, in an open area and in safe weather conditions

with wind speeds no greater than 20 mph.

6. Use a recovery system such as a flame-resistant or fireproof streamer or parachute so that it returns safely and undamaged and can be flown again.
7. Launch rockets with an electrical launch system and electrical motor igniters.
8. The launch system should have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.
9. Use a safe launch distance of at least 15 feet (6 meters) away from the launch pad for rockets with up to "D" size engines. Use 30 feet (1 meters) when launching larger rockets engines.
10. If the rocket misfires, remove the launcher's safety interlock or disconnect its battery. Wait 60 seconds after the last launch attempt before allowing anyone near the rocket.
11. Launch a rocket from a launch rod, tower, or rail that is pointed within 30 degrees of the vertical to ensure the rocket flies nearly straight up.
12. Use a blast deflector to prevent the engine's exhaust from hitting the ground.
13. Do not launch rockets at targets such as tall buildings, power lines or near airplanes.
14. Never put any flammable or explosive payload in a rocket.
15. Do not attempt to recover rockets from power lines, tall trees or other dangerous places.

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E. Nonionizing Radiation – Lasers:

Nonionizing radiation consists of electromagnetic radiation that lacks sufficient energy to ionize matter. These may include the use of lasers, microwaves and infrared radiation in the physics laboratory. Nonionizing radiation can cause injury if handled improperly.

The most common nonionizing radiation equipment used in physics laboratories is the laser. Safety specifications vary depending on the class of laser instrument being used. The following general safety specifications provide prudent advice and direction for use in high school physics courses:

1. Before operation, warn all individuals present of the potential hazard.
2. Use the laser away from areas where the uninformed and curious might be attracted by its operation.
3. In conspicuous locations inside and outside the work area and on doors giving access to the area, place hazardous warning signs indicating that a laser is in operation and may be hazardous.

4. Remove all watches and rings before changing or altering the experimental setup. Shiny jewelry can cause hazardous reflections.
5. Practice good housekeeping in the lab to ensure that no device, tool or other reflective material is left in the path of the beam.
6. Before a laser operation, prepare a detailed operating procedure outlining operation.
7. Cover all exposed wiring and glass on the laser with a shield to prevent shock and contain any explosions of the laser materials. Be sure all nonenergized parts of the equipment are grounded.
8. Set up the laser so that the beam path is not at normal eye level, i.e., below 3 feet (9 meters) or above 5 feet (2 meters).
9. Use shields to prevent strong reflections and the direct beam from going beyond the area needed for the demonstration or experiments.
10. Whenever a laser is operated outside the visible range (such as a CO_2 laser), a warning device must be installed to indicate its operation.
11. A key switch to lock the high voltage supply should be installed.
12. View holograms only with a diverged laser beam. Be sure the diverging lens is firmly attached to the laser.
13. Illuminate the area as brightly as possible to constrict the pupils of the observers.
14. The target of the beam should be a diffuse material capable of absorbing the beam and reflection
15. Do not at any time look into the primary beam of a laser.
16. Do not aim the laser with the eye. Direct reflection can cause eye damage.
17. Do not look at reflections of the beam. These, too, can cause retinal burns.
18. Do not use sunglasses to protect the eyes. If laser safety goggles are used, be certain they are designed for use with the laser being used.
19. Report any afterimage to a doctor, preferably an ophthalmologist who has had experience with retinal burns. Retinal damage is possible.
20. Do not leave a laser unattended.
21. Note on laser pointer use: Connecticut has the following general statute relative to laser pointers:

    Connecticut General Statutes (C.G.S.)

    § 53-206e. Limitation on sale and use of laser pointers

    (a) As used in this section, "laser pointer" means a hand-held device that emits a laser light beam and is designed to be used by the operator to indicate, mark or identify a specific position, place, item or object.

    (b) No person shall sell, offer to sell, lease, give or otherwise provide a laser pointer to a person under eighteen years of age, except as provided in subsection (d) of this section.

No person under eighteen years of age shall possess a laser pointer on school grounds or in any public place, except as provided in subsection (d) of this section.

(d) A person may temporarily transfer a laser pointer to a person under eighteen years of age for an educational or other lawful purpose provided the person to whom the laser pointer is temporarily transferred is under the direct supervision of a parent, legal guardian, teacher, employer or other responsible adult.

(e) No person shall shine, point or focus a laser pointer, directly or indirectly, upon or at another person in a manner that can reasonably be expected to cause harassment, annoyance or fear of injury to such other person.

(f) Any person who violates any provision of this section shall have committed an infraction.

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F. Pressurized and Vacuum Systems:

Pressurized gas cylinders can explode. Bell jars can implode. Use only pressurized or evacuated items that are designed for such an activity.

Working with vacuums has the potential of an implosion and the possible hazards of flying glass, splattering chemicals and fire. Potential risks must be carefully considered. Equipment at reduced pressure can be prone to rapid pressure changes forcing liquids through an apparatus.

For safety prevention, adopt the following safety protocols when dealing with pressurized and vacuum systems:

1. Always use safety glasses or goggles with ANSI Z81 ratings.
2. Procedures should always be effected inside a hood.
3. Place vacuum apparatus out of harm's way so an accidental hit is minimized. Placement of transparent plastic around the apparatus helps prevent injury from flying glass in case of an explosion.
4. Protect vacuum pumps with cold traps and vent the exhaust into an exhaust hood.
5. Assemble vacuum apparatus in a manner that avoids strain, particularly to the neck of the flask.
6. Do not allow water, solvents and corrosive gases to be drawn into vacuum systems.
7. Avoid putting pressure on a vacuum line to prevent stopcocks from popping out or glass apparatus from exploding.
8. Avoid using mechanical vacuum pumps for distillation or concentration

operations when dealing with volatile materials. A water aspirator should be used.

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G. Sound:

Usually physics laboratory equipment and activities do not normally produce noise levels requiring use of hearing protection. The OSHA Occupational Noise Standard (29 CFR 1910.95) has established a noise action level of 85 decibels (dBA) averaged over eight hours. Wind tunnels, motors, engines and other laboratory equipment used in physics laboratories have the potential to exceed the action level. Science teachers should monitor sound levels and provide hearing protection for themselves and students. It is advised that this be applied even below the action level.

7. Chemistry Laboratory Safety Specifications

A. Hazard Communication Standard (HCS) to conform with the United Nations' (UN) Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

The Globally Harmonized System (GHS) is an international approach to hazard communication, providing agreed criteria for classification of chemical hazards, and a standardized approach to label elements and safety data sheets. The GHS was negotiated in a multi-year process by hazard communication experts from many different countries, international organizations, and stakeholder groups. It is based on major existing systems around the world, including OSHA's Hazard Communication Standard and the chemical classification and labeling systems of other US agencies.

The result of this negotiation process is the United Nations' document entitled "Globally Harmonized System of Classification and Labeling of Chemicals," commonly referred to as The Purple Book. This document provides harmonized classification criteria for health, physical, and environmental hazards of chemicals. It also includes standardized label elements that are assigned to these hazard classes and categories, and provide the appropriate signal words, pictograms, and hazard and precautionary statements to convey the hazards to users. A standardized order of information for safety data sheets is also provided. These recommendations can be used by regulatory authorities such as OSHA to establish mandatory requirements for hazard communication, but do not constitute a model regulation. For additional information, go to the list of frequently asked questions.

The three major areas of change are in hazard classification, labels, and safety data sheets.

- Hazard classification: The definitions of hazard have been changed to provide specific criteria for classification of health and physical hazards, as well as classification of mixtures. These specific criteria will help to ensure that evaluations of hazardous effects are consistent across manufacturers, and that labels and safety data sheets are more accurate as a result.
- Labels: Chemical manufacturers and importers will be required to provide a label that includes a harmonized signal word, pictogram, and hazard statement for each hazard class and category. Precautionary statements must also be provided.
- Safety Data Sheets: Will now have a specified 16-section format.

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The table below summarizes the phase-in dates required under the revised Hazard Communication Standard (HCS):

Effective Completion Date	Requirement(s)	Who
December 1, 2013	Train employees on the new label elements and safety data sheet (SDS) format.	Employers
June 1, 2015* December 1, 2015	Compliance with all modified provisions of this final rule, except: The Distributor shall not ship containers labeled by the chemical manufacturer or importer unless it is a GHS label	Chemical manufacturers, importers, distributors and employers
June 1, 2016	Update alternative workplace labeling and hazard communication program as necessary, and provide additional employee training for newly identified physical or health hazards.	Employers
Transition Period to the effective completion dates noted above	May comply with either 29 CFR 1910.1200 (the final standard), or the current standard, or both	Chemical manufacturers, importers, distributors, and employers

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B. HazardClassifications:

(The following information is from *A Guide to The Globally Harmonized System of Classification and Labelling of Chemicals* (GHS)

Classification is the starting point for hazard communication. It involves the identification of the hazard(s) of a chemical or mixture by assigning a category of hazard/danger using defined criteria. The GHS is designed to be consistent and transparent. It draws a clear distinction between classes and categories in order to allow for "self classification." For many hazards a decision tree approach (e.g., eye irritation) is provided in the GHS Document. For several hazards the GHS criteria are semi-quantitative or qualitative. Expert judgment may be required to interpret these data.

Figure 3.1 Hazard Classification

The term "hazard classification is used to indicate that only the intrinsic hazardous properties of substances and mixtures are considered and involves the following 3 steps:

a) Identification of relevant data regarding the hazards of a substance or mixture;

b) Subsequent review of those data to ascertain the hazards associated with the substance or mixture; and

c) A decision on whether the substance or mixture will be classified as a hazardous substance or mixture and the degree of hazard, where appropriate, by comparison of the data with agreed hazard classification criteria.

Figure 3.1 shows the harmonized definition for hazard classification, which can be applied to all hazard categories in the system.

The data used for classification may be obtained from tests, literature, and practical experience. The GHS health and environmental hazard criteria/definitions are test method neutral. Accordingly, tests that determine hazardous properties conducted according to internationally recognized scientific principles can be used for purposes of hazard classification.

The GHS endpoints that cover physical, health and environmental hazards are listed in Figures 3.2 and 3.3, respectively. As mentioned earlier, the GHS hazard definitions are criteria-based. The following information provides an overview of the GHS definitions and classification criteria. It is recommended that the person responsible for GHS implementation consult the GHS Document or "Purple Book" for more complete information.

3.1 What are the GHS Physical Hazards?

The GHS physical hazards criteria, developed by the ILO and UNCETDG, were largely based on the existing criteria used by the UN Model Regulation on the Transport of Dangerous Goods. Therefore, many of the criteria are already being used on a worldwide basis. However, some additions and changes were necessary since the scope of the GHS includes all target audiences. The physical hazards classification process provides specific references to approved test methods and criteria for classification. The GHS physical hazard criteria apply to mixtures. It is assumed that mixtures will be tested for physical hazards.

In general, the GHS criteria for physical hazards are quantitative or semi-quantitative with multiple hazard levels within an endpoint. This is different from several of the existing systems that currently have qualitative criteria for various physical hazards (e.g., organic peroxide criteria under WHMIS and OSHA HCS). This could make classification under the GHS more consistent.

In developing GHS criteria for physical hazards it was necessary to define physical states. In the GHS,

- a gas is a substance or mixture which at 50°C has a vapor pressure greater than 300 kPa; or is completely gaseous at 20°C and a standard pressure of 101.3 kPa.
- a liquid is a substance or mixture that is not a gas and which has a melting point or initial melting point of 20°C or less at standard pressure of 101.3 kPa.
- a solid is a substance or mixture that does not meet the definitions of a

liquid or a gas.

The GHS physical hazards are briefly described below. For many of the physical hazards the GHS Document contains Guidance Sections with practical information to assist in applying the criteria.

Figure 3.2 Physical Hazard

- Explosives
- Flammable Gases
- Flammable Aerosols
- Oxidizing Gases
- Gases Under Pressure
- Flammable Liquids
- Flammable Solids
- Self-Reactive Substances
- Pyrophoric Liquids
- Pyrophoric Solids
- Self-Heating Substances
- Substances which, in contact with water emit flammable gases
- Oxidizing Liquids
- Oxidizing Solids
- Organic Peroxides
- Corrosive to Metals

3.1.1 Explosives

An explosive substance (or mixture) is a solid or liquid which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases. A pyrotechnic substance (or mixture) is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative, self-sustaining, exothermic chemical reactions.

Classification as an explosive and allocation to a division is a three-step process:

- Ascertain if the material has explosive effects (Test Series 1);
- Acceptance procedure (Test Series 2 to 4);
- Assignment to one of six hazard divisions (Test Series 5 to 7).

Table 3.1 Explosives

Division	Characteristics
1.1	Mass explosion hazard
1.2	Projection hazard
1.3	Fire hazard or minor projection hazard

1.4	No significant hazard
1.5	Very insensitive substances with mass explosion hazard
1.6	Extremely insensitive articles with no mass explosion hazard

Explosive properties are associated with certain chemical groups that can react to give very rapid increases in temperature or pressure. The GHS provides a screening procedure that is aimed at identifying the presence of such reactive groups and the potential for rapid energy release. If the screening procedure identifies the substance or mixture to be a potential explosive, the acceptance procedure has to be performed.

Substances, mixtures and articles are assigned to one of six divisions, 1.1 to 1.6, depending on the type of hazard they present. See, *UN Manual of Tests and Criteria* Part I Test Series 2 to 7. Currently, only the transport sector uses six categories for explosives.

3.1.2 Flammable Gases

Flammable gas means a gas having a flammable range in air at 20°C and a standard pressure of 101.3 kPa. Substances and mixtures of this hazard class are assigned to one of two hazard categories on the basis of the outcome of the test or calculation method (ISO 10156:1996).

3.1.3 Flammable Aerosols

Aerosols are any gas compressed, liquefied or dissolved under pressure within a non-refillable container made of metal, glass or plastic, with or without a liquid, paste or powder. The container is fitted with a release device allowing the contents to be ejected as solid or liquid particles in suspension in a gas, as a foam, paste or powder or in a liquid or gaseous state.

Aerosols should be considered for classification as either a Category 1 or Category 2 Flammable Aerosol if they contain any component classified as flammable according to the GHS criteria for flammable liquids, flammable gases, or flammable solids. Classification is based on:

- Concentration of flammable components;
- Chemical heat of combustion (mainly for transport/storage);
- Results from the foam test (foam aerosols) (mainly for worker/consumer);
- Ignition distance test (spray aerosols) (mainly for worker/consumer);
- Enclosed space test (spray aerosols) (mainly for worker/consumer).

Aerosols are considered:

- Nonflammable, if the concentration of the flammable components ≤ 1% and the heat of combustion is < 20 kJ/g.
- Extremely flammable, if the concentration of the flammable components >85% and the heat of combustion is ≥ 30 kJ/g to avoid excessive testing.

See the *UN Manual of Tests and Criteria* for the test method.

3.1.4 Oxidizing Gases

Oxidizing gas means any gas which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does. Substances and mixtures of this hazard class are assigned to a single hazard category on the basis that, generally by providing oxygen, they cause or contribute to the combustion of other material more than air does. The test method is ISO 10156:1996. Currently, several workplace hazard communication systems cover oxidizers (solids, liquids, gases) as a class of chemicals.

3.1.5 Gases under Pressure

Gases under pressure are gases that are contained in a receptacle at a pressure not less than 280 Pa at 20°C or as a refrigerated liquid. This endpoint covers four types of gases or gaseous mixtures to address the effects of sudden release of pressure or freezing which may lead to serious damage to people, property, or the environment independent of other hazards the gases may pose.

For this group of gases, the following information is required:

- vapor pressure at 50°C;
- physical state at 20°C at standard ambient pressure;
- critical temperature.

Criteria that use the physical state or compressed gases will be a different classification basis for some workplace systems.

Table 3.2 Gases under Pressure

Group	Criteria
Compressed gas	Entirely gaseous at -50°C
Liquefied gas	Partially liquid at temperatures > -50°C
Refrigerated liquefied gas	Partially liquid because of its low temperature
Dissolved gas	Dissolved in a liquid phase solvent

Data can be found in the literature, and calculated or determined by testing. Most pure gases are already classified in the UN Model Regulations. Gases are classified, according to their physical state when packaged, into one of four groups as shown in Table 3.2.

3.1.6 Flammable Liquids

Flammable liquid means a liquid having a flash point of not more than 93°C. Substances and mixtures of this hazard class are assigned to one of four hazard categories on the basis of the flash point and boiling point (See Table 3.3). Flash Point is determined by closed cup methods as provided in the GHS document, Chapter 2.5, paragraph 11.

Table 3.3 Flammable Liquids

Category	Criteria
1	Flash point < 23°C and initial boiling point = 35°C (95°F)
2	Flash point < 23°C and initial boiling point > 35°C (95°F)
3	Flash point = 23°C and = 60°C (140°F)
4	Flash point = 60°C (140°F) and = 93°C (200°F)

3.1.7Flammable Solids

Flammable solids are solids that are readily combustible, or may cause or contribute to fire through friction. Readily combustible solids are powdered, granular, or pasty substances which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly.

Substances and mixtures of this hazard class are assigned to one of two hazard categories (Table 3.4) on the basis of the outcome of the UN Test N.1 (*UN Manual of Tests and Criteria*). The tests include burning time, burning rate and behavior of fire in a wetted zone of the test sample.

Table 3.4 Flammable Solids

Category	Criteria
1	Metal Powders: burning time = 5 minutes Others: wetted zone does not stop fire & burning time < 45 seconds or burning > 2.2 mm/second
2	Metal Powders: burning time > 5 and = 10 minutes Others: wetted zone stop fire for at least 4 minutes & burning time < 45 seconds or burning rat > 2.2mm/second

3.1.8 Self-Reactive Substances

Self-reactive substances are thermally unstable liquids or solids liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air). This definition excludes materials classified under the GHS as explosive, organic peroxides or as oxidizing. These materials may have similar properties, but such hazards are addressed in their specific endpoints. There are exceptions to the self-reactive classification for material: (i) with heat of decomposition <300 J/g or (ii) with self-accelerating decomposition temperature (SADT) > 75°C for a 50 kg package.

Substances and mixtures of this hazard class are assigned to one of the seven 'Types', A to G, on the basis of the outcome of the UN Test Series A to H (*UN Manual of Tests and Criteria*). Currently, only the transport sector uses seven categories for self-reactive substances (Table 3.5).

Table 3.5 Self-Reactive Substances

Type	Criteria
A	Can detonate or deflagrate rapidly, as packaged.
B	Possess explosive properties and which, as packaged, neither detonates nor deflagrates, but is liable to undergo a thermal explosion in that package.
C	Possess explosive properties when the substance or mixture as package cannot detonate or deflagrate rapidly or undergo a thermal explosion.
D	• Detonates partially, does not deflagrate rapidly and shows no violent effect when heated under confinement; or • Does not detonate at all, deflagrates slowly and shows no violent effect when heated under confinement; or • Does not detonate or deflagrate at all and shows a medium effect when heated under confinement.
E	Neither detonates nor deflagrates at all and shows low or no effect when heated under confinement.
F	Neither detonates in the cavitated bubble state nor deflagrates at all and shows only a low or no effect when heated under confinement as well as low or no explosive power.
G	Neither detonates in the cavitated state nor deflagrates at all and shows non effect when heated under confinement nor any explosive power, provided that it is thermally stable (self-accelerating decomposition temperature is 60°C to 75°C for a 50 kg package), and, for liquid mixtures, a diluent having a boiling point not less than 150°C is used for desensitization.

Pyrophorics

3.1.9 Pyrophoric Liquids

A pyrophoric liquid is a liquid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air. Substances and mixtures of this hazard class are assigned to a single hazard category on the basis of the outcome of the UN Test N.3 (UN Manual of Tests and Criteria).

3.1.10 Pyrophoric Solids

A pyrophoric solid is a solid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air. Substances and mixtures of this hazard class are assigned to a single hazard category on the basis of the outcome of the UN Test N.2 (*UN Manual of Tests and Criteria)*.

3.1.11 Self-Heating Substances

A self-heating substance is a solid or liquid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat. This endpoint differs from a pyrophoric substance in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days). Substances and mixtures of this hazard class are assigned to one of two hazard categories on the basis of the outcome of the UN Test N.4 (*UN Manual of Tests and Criteria)*.

3.1.12 Substances which on Contact with Water Emit Flammable Gases

Substances that, in contact with water, emit flammable gases are solids or liquids which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities. Substances and mixtures of this hazard class are assigned to one of three hazard categories on the basis of test results (UN Test N.5 *UN Manual of Tests and Criteria*), which measure gas evolution and speed of evolution.

Table 3.6 Substances which on Contact with Water Emit Flammable Gases

Category	Criteria
1	=10 L/kg/1 minute
2	=20 L/kg/ 1 hour + < 10 L/kg/1 min
3	=1 L/kg/1 hour + < 20 L/kg/1 hour
Not classified	< 1 L/kg/1 hour

3.1.13 Oxidizing Liquids

An oxidizing liquid is a liquid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause or contribute to the combustion of other material. Substances and mixtures of this hazard class are assigned to one of three hazard categories on the basis of test results (UN Test O.2 *UN Manual of Tests and Criteria*) which measure ignition or pressure rise time compared to defined mixtures.

3.1.14 Oxidizing Solids

An oxidizing solid is a solid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause or contribute to the combustion of other material. Substances and mixtures of this hazard class are assigned to one of three hazard categories on the basis of test results (UN Test O.1 *UN Manual of Tests and Criteria*) which measure mean burning time and re compared to defined mixtures. Currently, several workplace hazard communication systems cover oxidizers (solids, liquids, gases) as a class of chemicals.

3.1.15 Organic Peroxides

An organic peroxide is an organic liquid or solid which contains the bivalent -0-0- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term also includes organic peroxide formulations (mixtures). Such substances and mixtures may:

- be liable to explosive decomposition;
- burn rapidly;
- be sensitive to impact or friction;
- react dangerously with other substances.

Substances and mixtures of this hazard class are assigned to one of seven 'Types', A to G, on the basis of the outcome of the UN Test Series A to H (*UN Manual of Tests and Criteria*). Currently, only the transport sector uses seven categories for organic peroxides.

Table 3.7 Organic Peroxides

Type	Criteria
A	Can detonate or deflagrate rapidly, as packaged.
B	Possess explosive properties and which, as packaged, neither detonates nor deflagrates rapidly, but is liable to undergo a thermal explosion in that package.
C	Possess explosive properties when the substance or mixture as packaged cannot detonate or deflagrate rapidly or undergo a thermal explosion.
D	• Detonates partially, does not deflagrate rapidly and shows no violent effect when heated under confinement; or • Does not detonate at all, deflagrates slowly and shows no violent effect when heated under confinement; or • Does not detonate or deflagrate at all and shows a medium effect when heated under confinement.
E	Neither detonates nor deflagrates at all and shows low or no effect when heated under confinement.
F	Neither detonates in the caviated bubble state nor deflagrates at all and shows only a low or no effect when heated under confinements as well as low or nonexplosive power.
G	Neither detonates in the caviated state nor deflagrates at all and shows no effect when heated under confinement nor any explosive power, provided that it is thermally stable (self-accelerating decomposition temperature is 60°C to 75°C for a 50 kg package), and, for liquid mixtures, a diluent having a boiling point not less than 150°C is used for desensitization.

3.1.16 Substances Corrosive to Metal

A substance or a mixture that by chemical action will materially damage, or even destroy, metals is termed 'corrosive to metal'. These substances or mixtures are classified in a single hazard category on the basis of tests (Steel: ISO 9328 (II): 1991 - Steel type P235; Aluminum: ASTM G31-72 (1990) - non-clad types 7075-T6 or AZ5GU-T66). The GHS criteria are a corrosion rate on steel or aluminum surfaces exceeding 6.25 mm per year at a test temperature of 55°C.

The concern in this case is the protection of metal equipment or installations in case of leakage (e.g., plane, ship, tank), not material compatibility between the container/tank and the product. This hazard is not currently covered in all systems.

3.2 What are the GHS Health and Environmental Hazards?

The GHS health and environmental hazard criteria represent a harmonized approach for existing classification systems (see Figure 3.3). The work at the OECD to develop the GHS criteria included:

- A thorough analysis of existing classification systems, including the scientific basis for a system and its criteria, its rationale and an explanation of the mode of use;
- A proposal for harmonized criteria for each category. For some categories the harmonized approach was easy to develop because the existing systems had similar approaches. In cases where the approach was different, a compromise consensus proposal was developed.
- Health and environmental criteria were established for substances and mixtures.

Figure 3.3

Health Hazard

- Acute Toxicity
- Skin Corrosion/Irritation
- Serious Eye Damage/Eye Irritation
- Respiratory or Skin Sensitization
- Germ Cell Mutagenicity
- Carcinogenicity
- Reproductive Toxicology
- Target Organ Systemic Toxicity - Single Exposure
- Target Organ Systemic Toxicity - Repeated Exposure
- Aspiration Toxicity

Environmental Hazard

- Hazardous to the Aquatic Environment
    - Acute aquatic toxicity
    - Chronic aquatic toxicity
        - Bioaccumulation potential
        - Rapid degradability

For additional information, check out OSHA's Web site.

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C. Ordering Chemicals – Safety Procedures:

With the cost of shipping, storing and disposing of chemicals, planning for ordering of chemicals is critical. The following safety procedures are recommended for ordering practices:

1. Estimate the amount of chemicals needed based on inventory.
2. Order only minimal amounts of chemicals. Think "micro-chemistry"!
3. Review SDS for all new chemicals.
4. Make sure laboratory ventilation system and/or fume hood exhaust will meet the needs for chemical use.
5. Make sure appropriate storage is available: flammable liquid cabinet, acid cabinet, chemical storeroom.

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D. Receiving Chemicals:

Safety procedures for receiving shipments of chemicals and their use include the following:

1. Purchase orders should have SDS requirements stated for all hazardous chemicals purchased.
2. Make sure chemicals are stable and secure for transporting.
3. Only transport chemicals with minimum exposure to building occupants.
4. Transport gas cylinders one at a time using an appropriate hand truck. Do not remove valve cap until the cylinder is in the storage location..
5. Do not accept any hazardous chemicals without an SDS.
6. Do not accept any hazardous chemicals without proper labeling.

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E. Storage of Chemicals:

1. All chemical shelving needs front edge lips of approximately 0.75-inches (9 centimeters) in height.
2. All chemical storage areas are considered secured areas and must have locks. Only science certified personnel, administrators or trained custodians should have access. Students are not to have access to any chemical storage areas.
3. Storage areas are to have appropriate ventilation (non-re-circulating) with a minimum of four room changes per hour.
4. All chemical storage shelving and cabinets are to be secured to the wall to prevent tipping over.
5. Chemicals should not be stored above eye level.

6. Have a spill control station near the chemical storage site.
7. All chemicals containers must be properly labeled, dated and in good condition in preparation for storage.
8. Chemicals are to be organized by compatibility, not alphabetically. Incompatible chemicals are to be stored separately.
9. Chemicals should be stored alphabetically within compatible groups.
10. Segregate chemicals by hazard class (flammable compressed gases, nonflammable compressed gases, flammable liquids, combustible liquids, flammable solids, corrosive acids, corrosive bases, oxidizers, organic peroxides, spontaneously combustible reactives, water reactives, explosives and radioactives).
11. Flammable liquids should be stored in National Fire Protection Association (NFPA) approved safety cans and cabinets.
12. Hazardous liquids should be stored within a secondary containment.
13. Chemicals should not be exposed to direct heat, sunlight or highly variable temperatures.
14. Never place large or heavy containers on high shelves.
15. Never store chemicals on tops of cabinets or on floors.

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F. Handling and Using Chemicals:

1. Be aware of safety equipment location in case of a chemical splash or spill including the chemical spill cart.
2. Review SDS and labels for hazards associated with a chemical before using it.
3. Do not eat or drink in the laboratory.
4. Use the buddy system. Never work alone without another staff member present.
5. Use appropriate personal protective equipment (PPE): chemical splash goggles, hand protections, apron, closed toed shoes. Flip flops and sandals are inappropriate footwear in the chemistry lab.
6. Never smell, taste or touch chemicals with bare hands.
7. Never return a chemical to original container once it has been removed.
8. Never leave hazardous chemicals or processes unattended.
9. Use good housekeeping practices. Keep areas clean and uncluttered.
10. Always clean up after completing the laboratory activity.
11. Always wash hands with soap and water after completing the laboratory activity.

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G. Chemical Disposal:

1. Chemicals are to be disposed of or recycled using environmentally safe procedures.
2. Read SDS for appropriate chemical disposal.
3. Place used chemicals or products in containers designed and labeled for that purpose
4. Label the container with appropriate chemical information – content and volume or mass.
5. Keep container closed unless filling.
6. Contact the school's facility department for appropriate disposal instructions.
7. Use only certified and approved chemical waste contractors.

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H. Chemical Labeling-National Fire Protection Association (NFPA) System:

The NFPA system of chemical labeling is characterized by a color coded diamond shaped symbol. It is designed to quickly identify safety hazards of the material and the degree of flammability, level of health and instability hazards. For a detailed explanation, visit the following Web sites:

The NFPA's Hazard Rating Diamond

NFPA 704 Hazard Rating System

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I. Chemical Labeling:

Under the revised HCS, once the hazard classification is completed, the standard specifies what information is to be provided for each hazard class and category. Labels will require the following elements:

- Pictogram: a symbol plus other graphic elements, such as a border, background pattern, or color that is intended to convey specific information about the hazards of a chemical. Each pictogram consists of a different symbol on a white background within a red square frame set on a point (i.e. a red diamond). There are nine pictograms under the GHS. However, only eight pictograms are required under the HCS.
- Signal words: a single word used to indicate the relative level of severity of hazard and alert the reader to a potential hazard on the label. The signal words used are "danger" and "warning." "Danger" is used for the more severe hazards, while "warning" is used for less severe hazards.

- Hazard Statement: a statement assigned to a hazard class and category that describes the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard.
- Precautionary Statement: a phrase that describes recommended measures to be taken to minimize or prevent adverse effects resulting from exposure to a hazardous chemical, or improper storage or handling of a hazardous chemical.

There are nine pictograms under the GHS to convey the health, physical and environmental hazards. The final Hazard Communication Standard (HCS) requires eight of these pictograms, the exception being the environmental pictogram, as environmental hazards are not within OSHA's jurisdiction. The hazard pictograms and their corresponding hazards are shown below.

Health Hazard	Flame	Exclamation Mark
 • Carcinogen • Mutagenicity • Reproductive Toxicity • Respiratory Sensitizer • Target Organ Toxicity • Aspiration Toxicity	 • Flammables • Pyrophorics • Self-Heating • Emits Flammable Gas • Self-Reactives • Organic Peroxides	 • Irritant (skin and eye) • Skin Sensitizer • Acute Toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritant • Hazardous to Ozone Layer (Non-mandatory)
Gas Cylinder	**Corrosion**	**Exploding Bomb**
 • Gases under Pressure	 • Skin Corrosion/ burns • Eye Damage • Corrosive to Metals	 • Explosives • Self-Reactives • Organic Peroxides
Flame over Circle	**Environment**	**Skull and Crossbones**
 • Oxidizers	 (Non-mandatory) • Aquatic Toxicity	 • Acute Toxicity (fatal or toxic)

For additional information, go to OSHA's Web site.

Hazardous Materials Identification System HMIS Hazardous Materials Identification System (HMIS) was developed by the National Paint & Coatings Association (NPCA) in concert with OSHA’s HazCom Standard. It allows employees to quickly know the type and degree of hazards associated with the chemical being used. However, it is not designed for emergency information like the NFPA system.

See the MSDS HyperGlossary and the American Coatings Association..

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J. Secondary Labels:

If chemicals are transferred from a stock bottle into a smaller container, the latter is known as a secondary container. Although OSHA does not require labeling of the secondary container in all instances (e.g., one person filling a secondary container from a properly labeled primary container for one shift, one person use only operation) per the hazard communications standard, it is prudent safety practice in the laboratory to do so. A good start is placing the name of the chemical, NFPA label system information and date.

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K. Safety Data Sheets (SDS):

The revised HCS requires that the information on the SDS is presented using consistent headings in a specified sequence.

Paragraph (g) of the final rule indicates the headings of information to be included on the SDS and the order in which they are to be provided. In addition, Appendix D indicates what information is to be included under each heading. The SDS format is the same as the ANSI standard format which is widely used in the U.S. and is already familiar to many employees.

The format of the 16-section SDS should include the following sections:

Section 1. Identification
Section 2. Hazard(s) identification
Section 3. Composition/information on ingredients
Section 4. First-Aid measures
Section 5. Fire-fighting measures
Section 6. Accidental release measures
Section 7. Handling and storage
Section 8. Exposure controls/personal protection
Section 9. Physical and chemical properties
Section 10. Stability and reactivity
Section 11. Toxicological information
Section 12. Ecological information
Section 13. Disposal considerations
Section 14. Transport information
Section 15. Regulatory information
Section 16. Other information, including date of preparation or last revision

Sections 12-15 may be included in the SDS, but are not required by OSHA.

Exposure Limits:

Exposure limits are designed to protect employees from excessive exposure to hazardous substances. The limits usually are relative to the concentration of a chemical in the air. However, they also may define limits for physical agents such as noise, radiation and heat. There are a variety of exposure limits established by professional safety organizations (American Industrial Hygiene Association), governmental organizations (OSHA, EPA) and chemical manufacturers. The information can usually be found on the SDS.

Legal Limits:

Permissible Exposure Limits (PELs) are established by OSHA, 29 CFR 1910.1000, and 1910.1001 through 1910.1450. They specify the maximum amount or concentration of a chemical to which a worker may be exposed.

These are defined in three ways:

1. Ceiling Limit (C): the concentration that must not be exceeded at any part of the workday
2. Short-Term Exposure Limit (STEL): the maximum concentration to which workers may be exposed for a short period of time (15 minutes)
3. Time-Weighted Average (TWA): the average concentration to which workers may be exposed for a normal, 8-hour workday.

Other Exposure Limits (legally unenforceable):

1. Immediately Dangerous to Life and Health (IDLH) – These are conditions that pose an immediate danger to health and life by exposure. These were originally established for decision relative to respirator use.
2. Threshold Limit Values (TLVs) – TLVs are prepared by American Conference of governmental Industrial Hygienists volunteer scientists. They show the level of exposure that workers can experience without an unreasonable risk of disease or injury.
3. Recommended Exposure Limits (RELs) – These are recommended by the National Institute for Occupational Safety and Health. They indicate the concentration of a substance to which a worker can be exposed for up to a 10-hour workday during a 40-hour work week without adverse effects. RELs tend to be more conservative than PELs or TLVs.
4. Workplace Environmental Exposure Limits (WEELs) – Developed by American Industrial Hygiene Association volunteers. WEELs are usually developed for chem- icals that are not widely used or for which little toxicity information is available
5. Company-Developed Limits – Developed by company scientists. These are usually based on only short-term studies of animals and generally intended for internal company use.

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L. Chemical Tracking System:

Chemical tracking systems are a chemical database which is used to characterize the life of chemicals used in the laboratory. They should cover the history of the chemical. Remember that schools own the chemical from the cradle to the grave! There are various ways to set up these systems from index cards to a computer-based system.

The following tracking fields are recommended:

1. Date of inventory

2. Date chemical received
3. Specific amount of each chemical
4. Name, formula and grade of each chemical printed on the container's label
5. Chemical hazard of each item [Safety Data Sheet (SDS) information and National Fire Protection Association (NFPA) hazard code]
6. Chemical Abstract Service (CAS) registry number
7. Source (supplier)
8. Container type
9. Hazard classification
10. Required storage conditions
11. Expiration date
12. Storage location of each chemical
13. Amount of chemical in the container

Regularly scheduled inventory inspections should be conducted to delete any inaccurate data in the system and dispose of outdated, unneeded, or deteriorated chemicals following the written Chemical Hygiene Plan.

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M. Centrifuge Operation:

Centrifuges are useful tools in the laboratory but need to be operated safely:

1. Only use a rotor before the manufacturer's expiration or safe-service date.
2. Keep a rotor-use log to prevent overuse. Check the manufacturer's recommendation or specifications as the parameters differ from one machine to another.
3. Clean rotors and buckets with only noncorrosive solutions.
4. Always ensure that loads are evenly balanced before doing a run.
5. Stop the centrifuge immediately if vibration occurs.
6. Never leave the centrifuge unattended.
7. If corrosive or alkaline materials have been run or spilled, be sure to wash affected parts of the centrifuge immediately and allow them to air dry.
8. Never attempt to open the door while the rotor is spinning or attempt to
9. Stop the rotor by hand.
10. Do not attempt to move the centrifuge while it is in operation.

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N. Electricity Hazards:

Proper grounding of flammable solvent containers and equipment is needed to prevent protection from static electricity and sparks. Dry air or low humidity fosters static electricity dangers. Sources of sparks and discharges include:

1. Hot plate temperature controls.
2. Brush motors.
3. Light and other control switches.
4. Pulling plugs on energized circuits.
5. Motion of plastic or synthetic materials including clothing.
6. Ungrounded metal objects such as screw drivers, metal electrode strips and aluminum foil.

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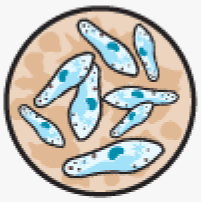
O. Glassware Hazards:

The leading cause of injury incidents in science laboratories usually involves the use of glassware. Borosilicate glassware is recommended for almost all laboratory work. The following procedures are recommended to reduce or eliminate injuries related to glassware in the chemistry laboratory:

1. Always inspect glassware for cracks and rough edges before using.
2. Discard damaged glassware in appropriate containers.
3. Whenever possible use other types of connections including latex tubing or plastic in lieu of glass.
4. For broken glass, wear appropriate hand protection, sweep small pieces into a pan and dispose in appropriate containers.
5. Always give hot glass time to cool before handling.
6. When inserting glass tubing into rubber stoppers or corks:
    a. Wear appropriate hand protection.
    b. Make sure ends are fire-polished.
    c. Lubricate the glass tubing with glycerol.
    d. Hold hands close together to limit motion of the glass.
7. Cutting glassware steps:
    a. Score the glass tubing 1/3 the way of the circumference with a triangular file using a single stroke.
    b. Wrap the tubing in paper towels or a cloth to protect the hands.
    c. Place thumbs on both sides of the score mark opposite the score.
    d. Push away from the body with even pressure on the tube.

8. Vacuum system glassware steps:
    a. Use only glassware that can withstand external pressure in the established atmosphere.
    b. Use Erlenmeyer-type round bottom vessels unless glassware is specifically designed for vacuum work.
    c. Always wrap vessels with duct tape to reduce glass fragment projectiles in case of an incident.
    d. Always inspect glassware and connections prior to creating the vacuum.
    e. Use a positive pressure relief device such as a liquid seal

8. Biology Laboratory Safety Specifications



A. Animal Care:

The use of animals in the science classroom can be a very rewarding educational experience. With animals comes humane care and appropriate animal husbandry practices. Abuse, mistreatment and neglect of animals are unacceptable. The following safety precautions should be addressed when dealing with animals in the laboratory:

1. Provide adequately sized cages.
2. Make sure cages are cleaned on a regular schedule.
3. Cages should be locked and in an environmentally comfortable location.
4. Check with the nurse for student allergies and make accommodations as needed.
5. Use gloves when handling vertebrates.
6. Always wash hands with soap and water after handling animals in the laboratory.
7. Immediately report and have medical examination of animal bites.
8. Should an animal die unexpectedly, a veterinarian should be contacted to evaluate the animal.
9. Never have poisonous animals in the laboratory.
10. Only secure animals from reputable suppliers.
11. Dispose of animal waste and cage materials in a hygienic manner.

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B. Biotechnology:

Biotechnology is an exciting relatively new area for course work in high schools. The following procedures for working with biotechnology foster a safer learning experience:

1. DNA and microbes should be handled as if they can cause infections.

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2. Handwashing hygiene is required before and after laboratory work by washing with antibacterial soap and water.
3. Gloves, chemical splash goggles and aprons are required.
4. Keep fingers away from eyes, nose and mouth.
5. Decontaminate work surfaces before and after laboratory activities and accidental spills.
6. Use only mechanical pipetting. Never use mouth pipetting techniques.
7. Decontaminate all labware such as glassware that was used in laboratory work by soaking in a 10 percent bleach solution for several hours.
8. Prior to disposal of biologicals, destroy all experimental microorganisms.

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C. Bloodborne Pathogens:

Bloodborne pathogens are bacteria, viruses and parasites found in human blood and other body fluids (Other Potentially Infectious Materials, or OPIMs). They can infect and cause disease in humans. The two pathogens recently receiving the greatest attention are the hepatitis B virus (HBV) and human immunodeficiency virus (HIV). Other pathogens that can also be of concern are herpes, meningitis, tuberculosis, Epstein-Barr virus, Lyme disease, malaria and syphilis, to name a few.

Bloodborne pathogens can be transferred by four different ways — direct, indirect, airborne and vector-borne. Direct and indirect are the biggest threat:

Direct — by touching body fluids from an infected person. This includes contact with lesions, open wounds or sores on the skin. Skin lining of the mouth, nose or throat, and eye contact/invasion, are additional avenues.

Indirect — by touching objects that have touched the blood or another body fluid of an infected person.

Allowing students to do blood work is not a prudent laboratory practice, given the risks involved. The Centers for Disease Control, OSHA and other regulatory agencies have clear prudent practices for this purpose.

Based on the means of transmission, life-threatening implications and an individual's right to confidentiality, the potential for bloodborne pathogen infection raises several issues for science teachers in laboratory situations. Although OSHA protects employees and not students, students involved in blood work create an unsafe working environment for employees. The OSHA Bloodborne Pathogen Standard states (29 CFR 1910.1030(d)(1): "Universal precautions shall be observed to prevent contact with blood or other potentially infectious materials." Teachers as employees can just as easily be exposed to bloodborne pathogens from students as they can from other employees. Bloodborne pathogens don't discriminate!

OSHA's Bloodborne Pathogens Standard addresses the blood hazards in the workplace. This standard covers all employees who can "reasonably be anticipated" to have contact with blood and other potentially infectious materials. Science teachers certainly fall under this category and are therefore covered under the bloodborne pathogens standard.

Science teachers, supervisors and their employers need to secure safe alternatives to laboratory activities such as human blood typing, cheek cell sampling and urinalysis.

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D. Dissections:

Should plant or animal dissections be used in a class for a laboratory or demonstration, the following safety precautions should be observed:

1. Share the MSDS information with students on the preservative prior to doing any dissection activity.
2. Contact the school nurse to determine if any students have allergies relative to specimen preparation chemicals.
3. Always used chemical splash goggles, gloves and aprons when doing dissection work.
4. Review emergency eye-wash procedures for chemical exposure prior to doing dissection work.
5. Always have the specimen completely rinsed prior to dissection to avoid contact with preservative chemicals.
6. Mount specimens on a dissecting pan in lieu of holding the specimen.
7. Use sharps such as dissection scalpels and blades with caution.
8. Cut away from the body — never toward the body.
9. Never remove any dissected parts from the laboratory.
10. Discard dissected parts in appropriate and labeled waste containers.
11. Always wash hands with soap and water after completing the dissection and cleanup.

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E. Electrophoresis:

Electrophoresis is a great opportunity for the laboratory study of DNA sequencing and more. However, electrophoresis units tend to operate at relatively high voltages. The following general safety procedures need to be addressed in dealing with this technology:

1. Avoid physical contact to unintentional grounding points and conductors like metal, water sources and jewelry.
2. Work should be located on nonconducting benches and floors. Rubber mats can serve as an insulating surface.

3. Use only ground-fault circuit interrupt (GFCI) protected electrical receptacles for power.
4. Locate the equipment in places where wires will not cause a trip and fall hazard.
5. Prior to use of equipment, inspect and correct items such as cracks, leaks and frayed wires.
6. Use caution making any physical contact with the apparatus. A thin layer of moisture acts as an electrical conductor.
7. Some electrophoresis devices have cooling components or apparatus. Do not contact any cooling apparatus with a gel as the tubing can be a current conductor. Always directly supervise the use of the equipment.
8. Exercise caution in working with power supplies that produce high voltage surges when first energized. Should the electrophoresis buffer spill or leak, stop the operation and clean up the spill immediately.
9. Use and post appropriate "Danger – High Voltage" warning signage on power supply and buffer tanks.
10. Upon completion of work, always wait 15 seconds for capacitor discharge after shutting off the power supply before making any disconnections or connections.

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F. Field Activities:

Field experiences in biology classes help provide applications to classroom curriculum studies. In preparing for a field experience, the following safety preparations and precautions should be taken:

1. In planning for field work, review board of education field trip policies.
2. Secure information from parents and the school nurse relative to student medical needs, allergies and contact information.
3. Written permission to obtain help for special needs should also be secured in advance.
4. If laboratory chemicals are used during the field work, MSDS sheets are required on the trip.
5. Communications are essential during field work. Bring a cell phone or two way long range radio to keep in touch with the school.
6. West Nile virus, Lyme disease and other insect-borne diseases are real threats. Use appropriate dress (long sleeve shirts, pants, closed-toe shoes or sneakers) and repellents for insects. Make sure that you've informed parents in advance about the use of repellents, so that potential allergies can be avoided.
7. Have a behavior contract that everyone understands, with consequences

that everyone will support.

8. Use chemical splash goggles and gloves when working in the field with river, pond or lake water, water testing chemicals and any other materials/activities that may prove hazardous to the eyes.
9. Use good sun sense by having students and teacher wear long sleeves, long pants, large-brimmed hats, sunglasses and sunscreen (SPF 30 minimum).

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G. Heat Sources:

1. Autoclaves/Pressure Cookers

   Autoclaves can be dangerous given high pressures and temperatures. Apply the following safety precautions when using autoclaves:

   a. Inspect the autoclave door and gaskets to make sure they are firmly locked in place.
   b. Post signage on autoclave warning of "hot surfaces, keep away."
   c. Never place combustible or flammable materials near or on the autoclave.
   d. Wear heat-resistant gloves, apron and chemical splash goggles.
   e. Do not leave the autoclave unattended during operation.
   f. Shut down the autoclave should there be any indication of a leak.

   Pressure cookers are less expensive than autoclaves and may be useful in simple laboratory sterilization procedures. They can be equally as dangerous as autoclaves at high pressures and temperatures. When using pressure cookers, follow these safety tips:

   a. Older pressure cookers have fewer safety features and have the potential to explode if not operating correctly. Always inspect the device to make sure clamps are securely attached, the gasket seal is in place, and the vent tube is clear.
   b. Make sure the vent tube is clear and operational.
   c. Never touch the cooker until it is cooled down.
   d. Never leave the cooker unattended during operation.

2. Bunsen Burners

   Bunsen burners can be dangerous as a heat source, given their hot flame. Use the following safety hints for a safer operation:

   a. Make sure hair is tied back.
   b. Always wear chemical splash goggles.
   c. Light the burner at arms length using an igniter or splint.

d. Do not operate the burner with acrylic nails.
e. Never leave the burner unattended.
f. Do not touch the burner until it has had time to cool off.
g. Do not operate the burner while igniting it.

3. Hot Plates

Hot plates are a major heat source in biology laboratories. They are easy to operate and less dangerous than gas burners.

a. Always inspect wiring on hot plates before use. Make sure insulation is in place and all prongs are on the plug.
b. Plug the hot plate into a GFCI protected wall receptacle.
c. Never touch a hot plate that has been in operation until it cools.
d. Never tie the cord around a heated hot plate.
e. Never leave a hot plate unattended.

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H. Microbes:

Microbe study in the laboratory requires special precautions given the opportunity of pathogenic bacteria exposure.

The following safety protocols should be enforced:

1. Personal protective equipment such as chemical splash goggles, lab coat or apron, and gloves are required during the laboratory activity.
2. Make sure all skin scratches and cuts are covered with bandages.
3. Before and after laboratory activities, wash the work area with disinfectant.
4. Absolutely no food or drink is allowed in the laboratory.
5. Keep sources of potential contamination such as pencils, hands and laboratory equipment away from body orifices such as mouth, ears and nose to prevent potential contamination.
6. Have disinfectant tray available for the discard of contaminated equipment such as pipettes, petri dishes and more.
7. Should there be an accidental spill of microbial organisms, immediately contain it with dry paper towels. Sterilize the paper towels and disinfect the area of the spill.
8. Report any accidents immediately to the instructor.
9. Only laboratory-grade cultures from a reputable scientific supplier should be used in the laboratory. No general survey collections should be cultured given the danger of pathogenic organisms. An effective alternative can be commercially prepared slides.

10. All bacteria cultures and petri plates should be autoclaved or microwaved prior to disposal.
11. Wash hands with antibacterial soap and water after completing the laboratory work and cleaning up.

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I. Microwaves:

Microwave ovens can be used as both a heating source and decontamination device. Simple safety precautions include the following:

1. Never operate the microwave oven when empty.
2. Always check the door seal prior to use to make sure it does not have a breach.
3. Persons with pacemakers should not be near the oven when operating.
4. Never place metal objects such as aluminum foil in the oven.
5. Do not put face near the oven door while operation.
6. Make sure the inside surface of the microwave is clean.
7. Post proper signage warning of microwave use.

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J. Plants:

The study of plants is both interesting and relevant to everyday life from food sources, oxygen production and energy sources. However, plants can also produce toxic substances that can put human life in harm's way. Be certain to follow the following safety plan when dealing with plants in the laboratory:

1. Check with the school nurse for potential allergy issues for students. Make accommodations as necessary.
2. Wear safety splash goggles, gloves and aprons when working with plants.
3. Never have poisonous plants or plants producing allergens in the laboratory.
4. Inform about the difference between edible and nonedible plants
5. No plant part should be tasted without specific direction from the teacher.
6. No parts of plants should be burned that have allergen-type oils such as poison ivy and poison oak.
7. Wash hands with soap and water after working with plants.

The Connecticut Department of Environmental Protection has made the following statement about non-native plants in its non-native invasive plant species policy:

> *Many non-native plants have been introduced intentionally or accidentally, with most having no deleterious effects on agricultural lands, waterways, wetlands, or conservation areas. Some non-native plants, however, exhibit an aggressive growth habit and can out-compete and displace native species. These are referred to as invasive. Invasive plants, also called harmful or noxious weeds, are a serious problem in Connecticut and elsewhere, reducing agricultural production, impairing recreation, and causing the loss of biological diversity.*

The Connecticut DEEP maintains a list of non-native invasive plant species. Before plant species are selected for use in the lab, check out the list of non-native invasive plant species before placing specimens out in the field.

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K. Refrigerator:

1. Never store food in any refrigerator or freezer used to store chemicals.
2. Refrigerators and freezers should be cleaned out on a regular basis.
3. Containers placed in a refrigerator or freezer should be completely sealed or capped, securely placed and labeled.
4. Avoid capping materials with aluminum foil, corks and glass stoppers.
5. All liquid chemicals should be stored in plastic trays.
6. All specimens should be stored in plastic bags with labels.
7. All items stored are to be appropriately labeled.
8. Review inventory on refrigerator/freezer contents to ensure compatibility of the contents.
9. Store only chemicals in amounts needed over a reasonable amount of time. Each chemical has a shelf-life and decomposition products that could be hazardous.
10. Remember that power outages and technology failure can have an impact on stored contents. Be aware of unusual odors or vapors.
11. Do not use glass beakers as lids for bottles.
12. Do not stack materials too high. Petri dishes/plates should be taped together and placed in a plastic bag.
13. Do not use graduated cylinders or volumetric flasks to store materials.
14. Refrigerators/freezers should be periodically inspected (i.e., at least monthly).
15. Post an up-to-date inventory on the refrigerator door.
16. If potentially infectious material is spilled, clean immediately with a disinfectant agent such as 70 percent isopropyl alcohol. Then, wipe down the area with soap and water.
17. The refrigerator/freezer must be properly grounded and a permanent

installation (i.e., no extension cords).

18. The refrigerator/freezer must be located away from lab exits.

9. Earth/Space Science Laboratory Safety Specifications

A. Astronomy:

Astronomical events such as viewing a solar eclipse are a great opportunity for learning, but safety precautions must be addressed.

1. Never look directly at the sun, including during a solar eclipse. Permanent eye damage is likely to take place.
2. Properly constructed pinhole viewers are a safe way to view the sun.
3. Never view the sun directly through binoculars or telescopes. This can cause blindness.
4. Never use sunglasses or exposed film to view the sun. They do not provide appropriate protection.

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B. Geology:

1. Rock and Mineral Study:

   Use the following precautions in working with rocks and minerals in the laboratory:

   a. Use appropriate personal protective equipment such as chemical splash goggles, gloves and aprons.

   b. Use a heavy canvas bag when breaking up rock/mineral samples.

   c. Use proper geologic hammer technique.

   d. Never work with radioactive rocks or specimens.

2. Geological field experience:

   Geological field experiences can be exciting and academically rewarding. The following safety precautions should be addressed in preparation for the trip:

   a. Secure information relative to medical conditions in preparation for the field activity from the school nurse and parents. Plan for administration of medication as necessary.

b. Wear appropriate clothing for the weather conditions.
c. Use sun sense by wearing appropriate clothing and head gear.
d. Use appropriate footwear such as boots or sneakers. Flip flops and sandals are unacceptable.
e. Wear safety glasses or goggles with an ANSI Z87.1 rating. Quarry and cliff type work require use of a safety helmet.
f. Tetanus shots are suggested.
g. Rocks and boulders should never be thrown or rolled on the field site. Never touch or try moving rotten trees.
h. Use caution when hammering rocks.
i. Use caution when standing near the foot of a cliff.

3. Ultraviolet Light

   The use of ultraviolet light for mineral study can be dangerous and should be done only as a teacher demonstration.

   a. Protect eyes and skin from exposure of ultraviolet transilluminators.
   b. Wear UV protection rated chemical safety goggles.
   c. Wear long sleeve shirts and lab coat with gloves.
   d. Only use a ground-fault circuit interrupter (GFCI) protected electrical receptacle for the lamp.
   e. Never operate the lamp near water sources.
   f. Never disassemble the lamp when plugged in – this is a high voltage power supply device.

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C. Water Studies:

1. Marine Field Trips:

   Marine field trips can be useful activities to expand and apply classroom studies. Consider the following safety procedures when planning:

   a. Review weather predictions and prepare appropriately.
   b. Make sure students do not have any open wounds, sores, cuts, etc. prior to going into the water.
   c. Review field hazards and emergency plans with students prior to the start of the activity.
   d. Use foot protection and chemical splash goggles
   e. Be aware of broken glass, fish hooks, rocks and other sharps.

f. Be watchful for poisonous or stinging marine dwellers like jellyfish, man-of-war.
g. Always establish boundaries for the area of study.
h. Provide life jacket for students entering water.
i. Use sun sense by applying sun screen and appropriate clothing/hat.
j. One adult should be on beach watch at all times in view of the boundary area.
k. Remember to bring a cell phone, first aid kit and blanket for emergencies.

2. Stream Tables:

   Stream tables can be can effective learning tools. Use the following safety precautions:

   a. Check the table out for leaks, including drain hoses.
   b. Wipe up any spilled water immediately to avoid creating a slip and fall hazard.
   c. Electrical receptacles should be GFCI protected.
   d. Have catch water buckets or receptacles available to catch overflow.

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D. Weather Studies:

Weather studies often involve building of weather station equipment. Plan on taking the following safety precautions:

1. Safety precautions need to be addressed and in place when using power tools, electrical devices, hand tools and sharp objects to build equipment. Be certain to file down or sand any sharp edges on materials used to construct weather station equipment after being cut. Never use equipment containing mercury such as thermometers or sling psychrometers.
2. Only adults with formal roof walking and fall protection training should be securing equipment on the roof of a building.