DOMAIN I. SCIENTIFIC INQUIRY AND PROCESSES

COMPETENCY 001 THE TEACHER UNDERSTANDS HOW TO SELECT AND MANAGE LEARNING ACTIVITIES TO ENSURE THE SAFETY OF ALL STUDENTS AND THE CORRECT USE AND CARE OF NATURAL RESOURCES, MATERIALS, EQUIPMENT, AND TECHNOLOGIES.

Skill 1.1 Uses current sources of information about laboratory safety, including safety regulations and guidelines for the use of science facilities, materials, and equipment.

Chemical purchase, use, and disposal

- Inventory all chemicals on hand at least annually. Keep the list up-to-date as chemicals are consumed and replacement chemicals are received.
- If possible, limit the purchase of chemicals to quantities that will be consumed within one year and that are packaged in small containers suitable for direct use in the lab without transfer to other containers.
- Label all chemicals to be stored with date of receipt or preparation and have labels initialed by the person responsible.
- Generally, bottles of chemicals should not remain:
  - Unused on shelves in the lab for more than one week. Move these chemicals to the storeroom or main stockroom.
  - Unused in the storeroom near the lab for more than one month. Move these chemicals to the main stockroom.
- Check shelf life of chemicals. Properly dispose of any out-dated chemicals.
- Ensure that the disposal procedures for waste chemicals conform to environmental protection requirements.
- Do not purchase or store large quantities of flammable liquids. Fire department officials can recommend the maximum quantities that may be kept on hand.
- Never open a chemical container until you understand the label and the relevant portions of the MSDS.

Chemical storage plan for laboratories

- Chemicals should be stored according to hazard class (ex. flammables, oxidizers, health hazards/toxins, corrosives, etc.).
- Store chemicals away from direct sunlight or localized heat.
- All chemical containers should be properly labeled, dated upon receipt, and dated upon opening.
- Store hazardous chemicals below shoulder height of the shortest person working in the lab.
- Shelves should be painted or covered with chemical-resistant paint or chemical-resistant coating.

- Shelves should be secure and strong enough to hold chemicals being stored on them. Do not overload shelves.
- Personnel should be aware of the hazards associated with all hazardous materials.
- Separate solids from liquids.

Below are examples of chemical groups that can be used to categorize storage. Use these groups as examples when separating chemicals for compatibility. Please note: reactive chemicals must be more closely analyzed since they have a greater potential for violent reactions. Contact Laboratory Safety if you have any questions concerning chemical storage.

Acids

- Make sure that all acids are stored by compatibility (ex. separate inorganics from organics).
- Store concentrated acids on lower shelves in chemical-resistant trays or in a corrosives cabinet. This will temporarily contain spills or leaks and protect shelving from residue.
- Separate acids from incompatible materials such as bases, active metals (ex. sodium, magnesium, potassium) and from chemicals which can generate toxic gases when combined (ex. sodium cyanide and iron sulfide).

Bases

- Store bases away from acids.
- Store concentrated bases on lower shelves in chemical-resistant trays or in a corrosives cabinet. This will temporarily contain spills or leaks and protect shelving from residue.

Flammables

- Approved flammable storage cabinets should be used for flammable liquid storage.
- You may store 20 gallons of flammable liquids per 100 sq.ft. in a properly fire separated lab. The maximum allowable quantity for flammable liquid storage in any size lab is not to exceed 120 gallons.
- You may store up to 10 gallons of flammable liquids outside of approved flammable storage cabinets.
- An additional 25 gallons may be stored outside of an approved storage cabinet if it is stored in approved safety cans not to exceed 2 gallons in size.
- Use only explosion-proof or intrinsically safe refrigerators and freezers for storing flammable liquids.

Peroxide-Forming Chemicals

- Peroxide-forming chemicals should be stored in airtight containers in a dark, cool, and dry place.
- Unstable chemicals such as peroxide-formers must always be labeled with date received, date opened, and disposal/expiration date.
- Peroxide-forming chemicals should be properly disposed of before the date of expected peroxide formation (typically 6-12 months after opening).
- Suspicion of peroxide contamination should be immediately investigated. Contact Laboratory Safety for procedures.

Water-Reactive Chemicals

- Water-reactive chemicals should be stored in a cool, dry place.
- Do not store water-reactive chemicals under sinks or near water baths.
- Class D fire extinguishers for the specific water-reactive chemical being stored should be made available.

Oxidizers

- Make sure that all oxidizers are stored by compatibility.
- Store oxidizers away from flammables, combustibles, and reducing agents.

Toxins

- Toxic compounds should be stored according to the nature of the chemical, with appropriate security employed when necessary.
- A "Poison Control Network" telephone number should be posted in the laboratory where toxins are stored. Color-coded labeling systems that may be found in your lab are shown below:

Hazard	**Color Code**
Flammables	Red
Health Hazards/Toxins	Blue
Reactives/Oxidizers	Yellow
Contact Hazards	White
General Storage	Gray, Green, Orange

Please Note: Chemicals with labels that are colored and striped may react with other chemicals in the same hazard class. See MSDS for more information. Chemical containers which are not color-coded should have hazard information on the label. Read the label carefully and store accordingly.

Disposal of chemical waste

Schools are regulated by the Environmental Protection Agency, as well as state and local agencies, when it comes to disposing of chemical waste. Check with your state science supervisor, local college or university environmental health and safety specialists, and the Laboratory Safety Workshop for advice on the disposal of chemical waste. The American Chemical Society publishes an excellent guidebook, ***Laboratory Waste Management, A Guidebook*** (1994).

The following are merely guidelines for disposing of chemical waste.

You may dispose of hazardous waste as outlined below. It is the responsibility of the generator to ensure hazardous waste does not end up in ground water, soil, or the atmosphere through improper disposal.

1. **Sanitary Sewer** - Some chemicals (acids or bases) may be neutralized and disposed to the sanitary sewer. This disposal option must be approved by the local waste water treatment authority prior to disposal. This may not be an option for some small communities that do not have sufficient treatment capacity at the waste water treatment plant for these types of wastes. Hazardous waste may NOT be disposed of in this manner. This includes heavy metals.

2. **Household Hazardous Waste Facility** - Waste chemicals may be disposed through a county household hazardous waste facility (HHW) or through a county contracted household hazardous waste disposal company. Not all counties have a program to accept waste from schools. Verify with your county HHW facility that they can handle your waste prior to making arrangements.

3. **Disposal Through a Contractor** - A contractor may be used for disposal of waste chemicals. Remember that you must keep documentation of your hazardous waste disposal for at least three years. This information must include a waste manifest, reclamation agreement or any written record which describes the waste and how much was disposed, where it was disposed and when it was disposed. Waste analysis records must also be kept when it is necessary to make a determination of whether waste is hazardous. **Any unknown chemicals should be considered hazardous!**

Skill 1.2 Recognizes potential safety hazards in the laboratory and in the field and knows how to prevent accidents and apply procedures, including basic first aid, for responding to accidents.

See Skill 1.3 below.

Skill 1.3 Employ safe practices in planning and implementing all instructional activities and designs and implements rules and procedures to maintain a safe learning environment.

The following is a summary of the requirements for chemical laboratories:

1) A dousing shower and eye-wash with a floor drain are required where students handle potentially dangerous materials.

2) Accessible fully-charged fire extinguishers of the appropriate type and fire blankets must be present if a fire hazard exists.

3) There must be a master control valve or switch accessible to and within 15 feet of the instructor's station for emergency cut-off of all gas cocks, compressed air valves, water, or electrical services accessible to students. Valves must completely shut off with a one-quarter turn. This master control is in addition to the regular main gas supply cut-off, and the main supply cut-off must be shut down upon activation of the fire alarm system.

4) A high capacity emergency exhaust system with a source of positive ventilation must be installed, and signs providing instructions must be permanently installed at the emergency exhaust system fan switch.

5) Fume hoods must contain supply fans that automatically shut down when the emergency exhaust fan is turned on

6) Rooms and/or cabinets for chemical storage must have limited student access and ventilation to the exterior of the building separate from the air-conditioning system. The rooms should be kept at moderate temperature, be well-illuminated, and contain doors lockable from the outside and operable at all times from the inside. Cabinet shelves must have a half-inch lip on the front and be constructed of non-corrosive material.

7) Appropriate caution signs must be placed at hazardous work and storage areas.

Therefore, all chemistry laboratories should be equipped with the following safety equipment. Both teachers and students should be familiar with the operation of this equipment.

Fire extinguisher

Fire extinguishers are rated for the type of fires they will extinguish. Chemical laboratories should have a combination ABC extinguisher along with a type D fire extinguisher. If a type D extinguisher is not available, a bucket of dry sand will do. Make sure you are trained to use the type of extinguisher available in your setting.

- **Class A** fires are ordinary materials like burning paper, lumber, cardboard, plastics etc.

- **Class B** fires involve flammable or combustible liquids such as gasoline, kerosene, and common organic solvents used in the laboratory.

- **Class C** fires involve energized electrical equipment, such as appliances, switches, panel boxes, power tools, hot plates and stirrers. Water is usually a dangerous extinguishing medium for class C fires because of the risk of electrical shock unless a specialized water mist extinguisher is used.

- **Class D** fires involve combustible metals, such as magnesium, titanium, potassium and sodium as well as pyrophoric organometallic reagents such as alkyllithiums, Grignards and diethylzinc. These materials burn at high temperatures and will react violently with water, air, and/or other chemicals. Handle with care!!

- **Class K** fires are kitchen fires. This class was added to the NFPA portable extinguishers Standard 10 in 1998. Kitchen extinguishers installed before June 30, 1998 are "grandfathered" into the standard.

Some fires may be a combination of these! Your fire extinguishers should have ABC ratings on them. These ratings are determined under ANSI/UL Standard 711 and look something like "3-A:40-B:C." Higher numbers mean more firefighting power. In this example, the extinguisher has a good firefighting capacity for Class A, B and C fires. NFPA has a brief description of UL 711 if you want to know more.

Eyewash

In the event of an eye injury or chemical splash, use the eyewash immediately.

Help the injured person by holding their eyelids open while rinsing. Rinse copiously and have the eyes checked by a physician afterwards.

Fire blanket

A fire blanket can be used to smother a fire. However, use caution when using a fire blanket on a clothing fire. Some fabrics are polymers that melt onto the skin. Use of a safety shower is the best method for extinguishing clothing on fire.

Safety shower

Use a safety shower in the event of a chemical spill or fire. Pull the overhead handle and remove clothing that may be contaminated with chemicals, to allow the skin to be rinsed.

Eye protection

Everyone present must wear eye protection whenever anyone in the laboratory is performing any of the following activities:

1) Handling hazardous chemicals
2) Handling laboratory glassware
3) Using an open flame.

Safety glasses do not offer protection from splashing liquids. Safety glasses appear similar to ordinary glasses and may be used in an environment that only requires protection from **flying fragments**. Safety glasses with side-shields offer additional protection from **flying fragments approaching from the side**.

Safety goggles offer protection from both flying fragments and splashing liquids. **Only safety goggles** are suitable for eye protection where **hazardous chemicals** are used and handled. Safety goggles with no ventilation (type G) or with indirect ventilation (type H) are both acceptable. Goggles should be marked "Z87" to show they meet federal standards.

Skin protection

Wear gloves made of a material known to resist penetration by the chemical being handled. Check gloves for holes and the absence of interior contamination. Wash hands and arms and clean under fingernails after working in a laboratory.

Wear a lab coat or apron. Wear footwear that completely covers the feet.

Ventilation - Using a Fume Hood

A fume hood carries away vapors from reagents or reactions you may be working with. Using a fume hood correctly will reduce your personal exposure to potentially harmful fumes or vapors. When using a fume hood, keep the following in mind:

- Place equipment or reactions as far back in the hood as is practical. This will improve the efficiency of fume collection and removal.
- Turn on the light inside the hood using the switch on the outside panel, near the electrical outlets.
- The glass sash of the hood is a safety shield. The sash will fall automatically to the appropriate height for efficient operation and should not be raised above this level, except to move equipment in and out of the hood. Keep the sash between your body and the inside of the hood. If the height of the automatic stop is too high to protect your face and body, lower the sash below this point. Do not place your head inside a hood or climb inside a hood.
- Wipe up all spills immediately. Clean the glass of your hood if a splash occurs.
- When you are finished using a hood, lower the sash to the level marked by the sticker on the side.

Work habits

- Never work alone in a laboratory or storage area.
- Never eat, drink, smoke, apply cosmetics, chew gum or tobacco, or store food or beverages in a laboratory environment or storage area.
- Keep containers closed when they are not in use.
- Never pipet by mouth.
- Restrain loose clothing and long hair and remove dangling jewelry.
- Tape all Dewar flasks with fabric-based tape.
- Check all glassware before use. Discard it if chips or star cracks are present.
- Never leave heat sources unattended.
- Do not store chemicals and/or apparatus on the lab bench or on the floor or aisles of the lab or storage room.
- Keep lab shelves organized.
- Never place a chemical, not even water, near the edges of a lab bench.
- Use a fume hood that is known to be in operating condition when working with toxic, flammable, and/or volatile substances.
- Never put your head inside a fume hood.
- Never store anything in a fume hood.
- Obtain, read, and be sure you understand the MSDS (see below) for each chemical that is to be used before allowing students to begin an experiment.
- Analyze new lab procedures and student-designed lab procedures in advance to identify any hazardous aspects. Minimize and/or eliminate these components before proceeding. Ask yourself these questions:
    - What are the hazards?
    - What are the worst possible things that could go wrong?
    - How will I deal with them?
    - What are the prudent practices, protective facilities and equipment necessary to minimize the risk of exposure to the hazards?
- Analyze close calls and accidents to eliminate their causes and prevent them from occurring again.
- Identify which chemicals may be disposed of in the drain by consulting the MSDS or the supplier. Clear one chemical down the drain by flushing with water before introducing the next chemical.
- Preplan for emergencies:
    - Keep the fire department informed of your chemical inventory and its location.
    - Consult with a local physician about toxins used in the lab and ensure that your area is prepared in advance to treat victims of toxic exposure.
    - Identify devices that should be shut off if possible in an emergency.
    - Inform your students of the designated escape route and alternate route.

Substitutions

- When feasible, substitute less hazardous chemicals for chemicals with greater hazards in experiments.
- Dilute substances when possible instead of using concentrated solutions.
- Use lesser quantities instead of greater quantities in experiments when possible.
- Use films, videotapes, computer displays, and other methods rather than experiments involving hazardous substances.

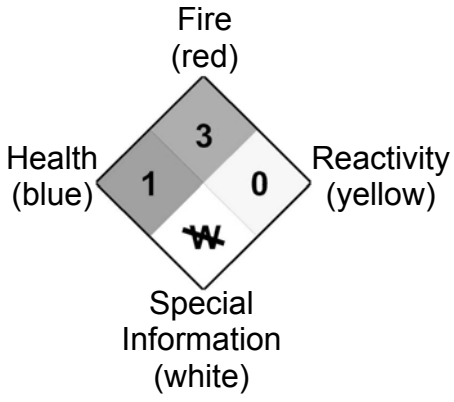
Label information

Chemical labels contain safety information in four parts:

1) There will be a signal word. From most to least potentially dangerous, this word will be "Danger!" "Warning!" or "Caution."
2) Statements of hazard (e.g., "Flammable," "May Cause Irritation") follow the signal word. Target organs may be specified.
3) Precautionary measures are listed such as "Keep away from ignition sources" or "Use only with adequate ventilation."
4) First aid information is usually included, such as whether to induce vomiting and how to induce vomiting if the chemical is ingested.

Chemical hazard pictorial

Several different pictorials are used on labels to indicate the level of a chemical hazard. The most common is the **"fire diamond" NFPA (National Fire Prevention Association) pictorial** shown below. A zero indicates a minimal hazard and a four indicates a severe risk. Special information includes if the chemical reacts with water, **OX** for an oxidizer, **COR ACID** for a corrosive acid, and **COR ALK** for a corrosive base. The "Health" hazard level is for **acute toxicity only**.



Pictorials are designed for **quick reference in emergency situations**, but they are also useful as minimal summaries of safety information for a chemical. They are not required on chemicals you purchase, so it's a good idea to add a label pictorial to every chemical you receive if one is not already present. **The entrance to areas where chemicals are stored should carry a fire diamond label** to represent the materials present.