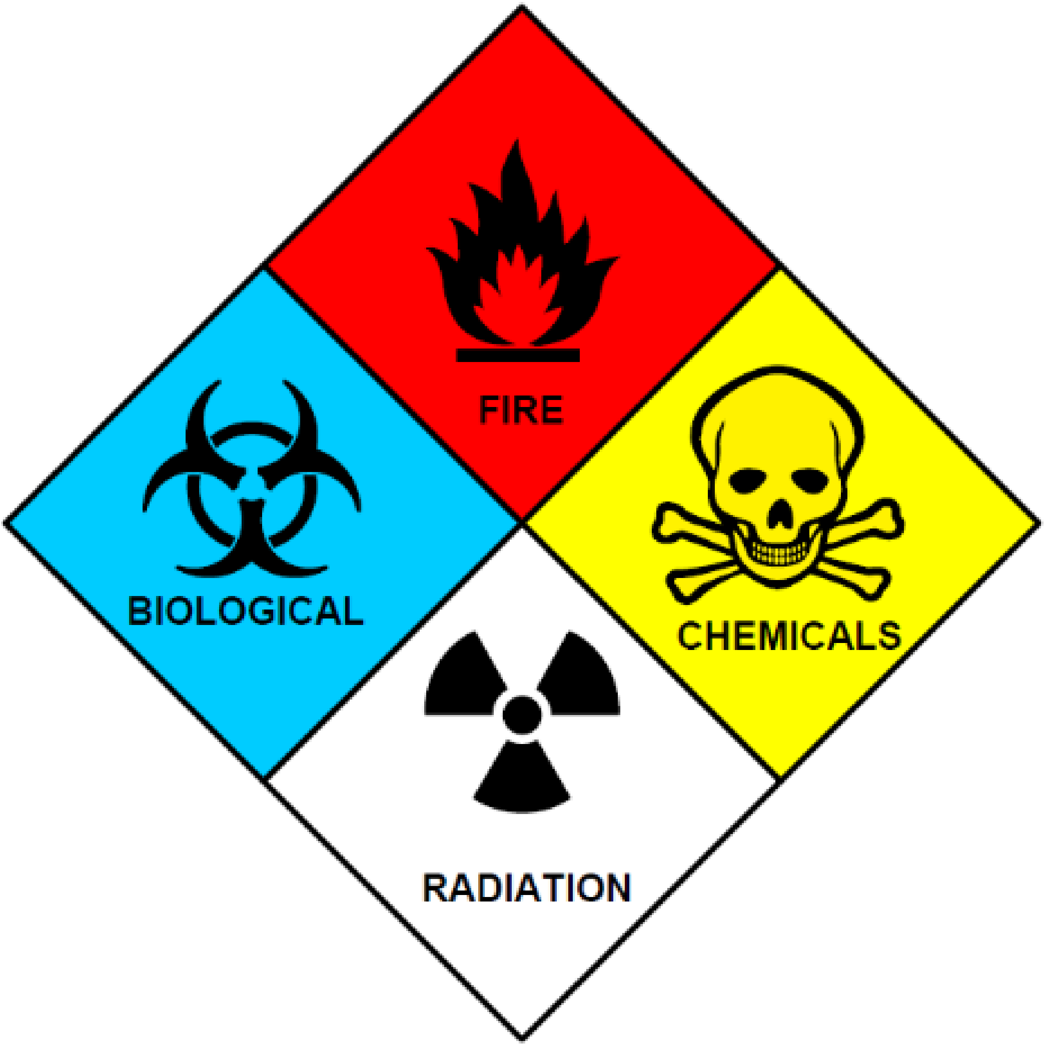
Department of Agricultural Research
Division of Crops
Section of Plant Protection and Quarantine

PLANT PROTECTION AND QUARANTINE LABORATORY SAFETY MANUAL



Lesotho Plant Protection and Quarantine

Be Safe & Enjoy Research

This laboratory safety manual is compiled to be used as a binding document for all personnel working in Plant Protection and Quarantine Laboratories to ensure safe work conduct and practices. It provides basic information about hazards that may be encountered in the laboratories and safety precautions to prevent accidents and minimize exposure to hazardous chemicals and equipment. It is important that each of laboratory workers be familiar with the contents of the manual and the procedures for obtaining safety information need to curry out assignments safely.

One of the most fundamental aspects of safety in practical research is good laboratory housekeeping., which include the proper storage and handling of chemicals, gas cylinders and electrical equipment amongst others. There are two golden rules in developing a safe productive environment:

1. Whenever you use a laboratory, it is your full responsibility to see that unsafe conditions are corrected immediately.
2. Always leave a laboratory in a better condition that you found it.

If we all take this level of personal responsibility, our section can only improve. This manual was prepared and approved in 2019.

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1. Introduction

In order to provide a safe and healthful workplace for the laboratory workers and other employees with the Department of Agricultural Research, the Section of Plant Protection and Quarantine has implemented the use of Laboratory Safety Manual (LSM). LMS is referred to as a written curriculum that specifies procedures, laboratory equipment, personal protective equipment and good work practices that assist in protecting employees from health hazards associated with the use of chemicals and other hazardous materials in the workplace. It is the duty of the principle investigators to ensure that the employees and volunteers within the workplace understand the LMS and standard operating procedures (SOPs) associated with the duties within the laboratory.

The primary goal of this curriculum is to ensure the safety and wellbeing of the Department of Agricultural Research, laboratory instructors, other staff and the visiting public will not be compromised in any of the Plant Protection and Quarantine Laboratories. To accomplish this, PPQ section is committed to achieve the following goals:

1. Provide the necessary facilities, staff, and equipment for safety.
2. Minimize all chemical exposures.
3. Protect the environment from hazardous chemicals and wastes.
4. Institute a Laboratory Safety Manual.
5. Conduct laboratory inspections to ensure these goals are being met.

2. General Laboratory Safety Procedures

MUST DO

- ✓ Know the potential hazards of the materials used in the laboratory. Review the safety data sheet (SDS) and container label prior to using a chemical.
- ✓ Know the location of safety equipment such as telephones, emergency call numbers, emergency showers, eyewashes, fire extinguishers, fire alarms, first aid kits, and spill kits.

- ✓ Review your laboratory's emergency procedures with your laboratory manager to ensure that necessary supplies and equipment are available for responding to laboratory accidents.
- ✓ Practice good housekeeping to minimize unsafe work conditions such as obstructed exits and safety equipment, cluttered benches and hoods, and accumulated chemical waste.
- ✓ Wear the appropriate personal protective equipment (PPE) for the chemicals you are working with. This includes eye protection, lab coat, gloves, and appropriate foot protection (no sandals or open-toed shoes). Gloves must be made of a material known to be resistant to permeation by the chemical in use.
- ✓ Shoes must cover the entire foot. Open toed shoes and sandals are inappropriate footwear in laboratories. Fabric and athletic shoes offer little or no protection from chemical spills. Leather shoes with slip-resistant soles are recommended.
- ✓ Street clothing is to be chosen so as to minimize exposed skin below the neck. Long pants and shirts with sleeves are examples of appropriate clothing. Avoid rolled up sleeves. Shorts (including cargo shorts), capris and, mini-skirts are inappropriate clothing in laboratories. Tank tops, sleeveless shirts and midriff-length shirts are not appropriate if not covered by a full-length laboratory coat and must not be worn if wearing an apron alone. Synthetic fabrics must be avoided in high-hazard areas where flammable liquids and reactive chemicals are utilized.
- ✓ Contact lenses are not recommended but are permitted. Appropriate safety eyewear is still required for those that use contact lenses.
- ✓ Wash skin promptly if contacted by any chemical, regardless of corrosivity or toxicity.
- ✓ Label all new chemical containers with the date received and date opened.
- ✓ Label and store chemicals properly. All chemical containers must be labelled to identify the container contents (no abbreviations or formulas) and should identify hazard information. Chemicals must be stored by hazard groups and chemical compatibilities.
- ✓ Use break-resistant bottle carriers when transporting chemicals in glass containers that are greater than 500 millilitres. Use lab carts for multiple containers. Do not use unstable carts.

- ✓ Use fume hoods when processes or experiments may result in the release of toxic or flammable vapours, fumes, or dust.
- ✓ Restrain and confine long hair and loose clothing. Pony-tails and scarves used to control hair must not present a loose tail that could catch fire or get caught in moving parts of machinery.

MUST NOT DO

- Eat, drink, chew gum, or apply cosmetics in rooms or laboratories where chemicals are used or stored.
- Store food in laboratory refrigerators, ice chests, cold rooms, or ovens.
- Drink water from laboratory water sources.
- Use laboratory glassware to prepare or consume food.
- Smell chemicals, taste chemicals, or pipette by mouth.
- Work alone in the laboratory without prior approval from the laboratory manager. Avoid chemical work or hazardous activities at night or during off-hours. Have a partner for assistance (use the "buddy-system") at night or during off-hours.
- Leave potentially hazardous experiments or operations unattended without prior approval from the laboratory manager. In such instances, the lights in the laboratory should be left on and emergency phone numbers posted at the laboratory entrance.

3. Procedure for proper labelling, storage and management of chemicals

Proper chemical labelling and storage are essential for a safe laboratory work environment. Inappropriate storage of incompatible or unknown chemicals can lead to spontaneous fire and explosions with the associated release of toxic gases. To minimize these hazards, chemicals in the laboratory must be segregated properly.

3.1. Labelling of chemicals

- ➢ Manufacturer chemical labels must never be removed or defaced until the chemical is completely used.

- All secondary chemical and waste containers must be clearly labelled with the full chemical name(s). No abbreviations or formulas.
- Small containers that are difficult to label such as 1-10 ml vials and test tubes can be numbered, lettered, or coded as long as an associated log is available that identifies the chemical constituents. Groups of small containers can be labelled as a group and stored together.
- Unattended beakers, flasks, and other laboratory equipment containing chemicals used during an experiment must be labelled with the full chemical name(s).
- All chemicals should be labelled with the date received and date opened.
- All laboratory chemical waste containers must be labelled with the name of the chemicals contained.
- All full waste containers must be disposed of promptly. Waste containers must **NOT** be filled to more than 90% of their capacity.
- Chemical storage areas such as cabinets, shelves and refrigerators may be labelled to help the laboratory personnel identify the hazardous nature of the chemicals stored within the area (e.g., flammables, corrosives, oxidizers, water reactive, toxins, carcinogens, and reproductive toxins).

3.2. Safety Data Sheets

Safety data sheets (SDS) for all laboratory chemicals are required to be maintained in the laboratory.

- The SDS for the exact chemical or mixture provided by the manufacturer of the product must be available. The chemical identity and manufacturer found on the label must match the chemical identity and manufacturer found on the SDS.
- All personnel must know how to access the SDS whether they are maintained on paper or electronically.
- All personnel must know how to read and understand an SDS.

3.3. Storage of chemicals

- A defined storage place should be provided for each chemical and the chemical should be returned to that location after each use.
- Chemical containers must be in good condition before they are stored. Containers must be managed to prevent leaks.
- Chemicals (including waste) must be separated and stored according to their hazard group and specific chemical incompatibilities. Chemicals within the same hazard group can be incompatible, therefore, it is important to review the chemical label and SDS to determine the specific storage requirements and possible incompatibilities.
- Special attention should be given to the storage of chemicals that can be classified into two or more hazard groups. For example, acetic acid and acetic anhydride are both corrosive and flammable. Additionally, nitric and perchloric acids are both corrosive and strong oxidizers. Separate organic acids from oxidizing acids using secondary tubs or trays in the corrosives' cabinet. Check SDS for proper storage procedures.
- Chemicals should be separated by distance. Physical barriers such as storage cabinets and secondary containers should be used to prohibit contact of incompatible chemicals in the event that they are accidentally released or spilled.
- Secondary containers are highly recommended for the storage of liquid chemicals. Secondary containers must be made of a material that is compatible with the chemical(s) it will hold and must be large enough to contain the contents of the largest container.
- Liquids should not be stored above dry chemicals unless they are stored in secondary containers.
- Storage of chemicals within hoods and on bench-tops should be avoided.
- Stored chemicals should not be exposed to heat or direct sunlight.
- Storage shelves and cabinets should be secure to prevent tipping. Shelving should contain a front-edge door to prevent containers from falling.
- Flammable and corrosive storage cabinets should be used when possible.
- Flammable liquids in quantities exceeding a total of 10 gallons in each laboratory must be stored in an approved flammable storage cabinet.

- Only explosion-proof or laboratory-safe refrigerators may be used to store flammable liquids.
- Liquid chemicals should be stored below eye level to avoid accidental spills.
- Chemicals must not be stored in areas where they can be accidentally broken and spilled such as on the floor or on the edge of a bench top.
- Chemicals must not be stored in areas where they obstruct aisles, exits, and emergency equipment.

<u>HAZARD GROUPS</u>

∗ Flammable/Combustible liquids
∗ Flammable solids
∗ Inorganic acids
∗ Organic acids
∗ Oxidizing acids (nitric, etc.)
∗ Caustics (bases)
∗ Oxidizers
∗Water reactives
∗Air reactives

∗ Unstable (shock-sensitive, explosive)
∗ Carcinogens & reproductive toxins
∗ Toxins, poisons
∗ Non-toxics
∗ Gases:
Toxic gases
Flammable gases
Oxidizing gases
Corrosive gases
Inert gases

3.4. Chemical Inventory Management

All chemicals must be inventoried. Inventories provide a method for tracking chemicals for ordering and re-ordering, waste disposal, complying with maximum allowable quantity limits in accordance with hazard communication, community right-to-know requirements, and tracking dangerous or time-sensitive chemicals for safety and security reasons.

Inventories should contain all pertinent information including the following data:

- Chemical name (synonym or trade name found on the SDS), if mixture list composition and percent of components.
- Chemical abstract service (CAS) number.

- Manufacturer.
- Product number.
- Physical state.
- Hazard class.
- Container size.
- Units of measure.
- Quantity or number of containers.
- Location (e.g., building, room number, cabinet).
- Receiving date.
- Opened container date.
- Expiration date.

Other information such as cost can be recorded as necessary for accounting purposes. Expiration dates are of particular importance for time-sensitive chemicals that can become dangerous with age. Several noteworthy time-sensitive laboratory chemicals include:

- Chemicals that form peroxides.
- Picric acid and other multi-nitro aromatics.
- Chloroform.
- Anhydrous hydrogen fluoride and hydrogen bromide.
- Liquid hydrogen cyanide.
- Formic acid.
- Alkali metals (such as potassium, sodium, and lithium).

Use the following guidelines to manage laboratory chemicals including time-sensitive materials:

3.4.1. Acquisition control

- Do not hoard chemicals.
- Do not over-purchase quantities.
- Use just-in-time purchasing whenever possible.
- Dispose of unused portions.

3.4.2. Research the literature and safety data sheet (SDS) information

- Define storage conditions.
- Consider refrigeration requirements or other storage options.
- Consider chemical incompatibilities.

3.4.3. Define unsafe conditions such as:

- Temperature or humidity extremes.
- Peroxide concentrations greater than 100 ppm.
- Dry picric acid.
- Expiration dates.

3.4.4. Track laboratory chemicals

- Maintain a chemical inventory and check expiration dates regularly.
- Define inspection interval for each chemical.
- Log the date of inspection and re-inspect without fail.
- Manage expired or unsafe chemicals.
- Never place chemicals where they will become lost or forgotten.
- Do NOT touch lost time-sensitive chemicals.

4. Chemical fume hood - Procedures for proper and safe use

Chemical fume hoods are one of the most important items of safety equipment present within the laboratory. Chemical fume hoods serve to control the accumulation of toxic, flammable, and offensive vapours by preventing their escape into the laboratory atmosphere. Additionally, fume hoods provide physical isolation and containment of chemicals and their reactions and thus serve as a protective barrier (with the sash closed) between laboratory personnel and the chemical or chemical process within the hood.

- A chemical fume hood must be used for any chemical procedures that have the potential of creating:
  a) Airborne chemical concentrations that might approach permissible exposure limits (PELs) for an occupational safety and health administration (OSHA) regulated

substance. These substances include carcinogens, mutagens, teratogens, and other toxins.

b) Flammable/combustible vapours approaching one-tenth the lower explosive limit (LEL). The LEL is the minimum concentration (percent by volume) of the fuel (vapour) in the air at which a flame is propagated when an ignition source is present.

c) Explosion or fire hazards.

d) Odours that are annoying to personnel within the laboratory or adjacent laboratory/office units.

- Hoods must be closed when unattended.
- The sash opening must be positioned no higher than the operating height (or half open) when the hood is being used with chemicals present or when chemical manipulations are performed. Place the sash in front of the face to protect the persons breathing zone near the nose and mouth from chemical contaminants released within the fume hood. When working with hazardous chemicals, the hood sash should always be positioned so that it acts as a protective barrier between laboratory personnel and the chemicals.
- The set-up position (fully open) is only used to place equipment in the hood when no chemicals are present. Do not fully open the sash when chemicals are present.
- Chemicals and equipment (apparatus, instruments, etc.) should be placed at least 6 inches (15 cm) from the front edge of the hood.
- Chemical fume hoods must be kept clean and free from unnecessary items and debris at all times. Solid material (paper, tissue, aluminium foil, etc.) must be kept from obstructing the rear baffles and from entering the exhaust ducts of the hood.
- Minimize the number of bottles, beakers and equipment used and stored inside the hood because these items interfere with the airflow across the work surface of the hood.
- Chemicals should not be stored in a hood because they will likely become involved if there is an accidental spill, fire or explosion in the hood, thus creating a more serious problem. Fume hoods are not flammable cabinets and do not offer fire protection for materials stored inside.

- Laboratory personnel must not extend their head inside the hood when operations are in progress.
- The hood must not be used for waste disposal (evaporation).
- Hoods must be monitored by the user to ensure that air is moving into the hood. A small piece of yarn can be taped to the hood sash as a visual indicator that the hood is pulling air. Any hoods that are not working properly must be taken out for service.

5. Corrosive chemicals – Procedures for safe handling and storage

Corrosives (liquids, solids, and gases) are chemicals that cause visible destruction or irreversible alterations to living tissue by chemical action at the site of contact. Corrosive effects can occur not only to the skin and eyes but also to the respiratory tract through inhalation and to the gastrointestinal tract through ingestion. Corrosive liquids have a high potential to cause external injury to the body, while corrosive gases are readily absorbed into the body through skin contact and inhalation. Corrosive solids and their clouds of dust can damage tissue by dissolving rapidly in moisture on the skin or within the respiratory tract when inhaled. In order to minimize these potential hazards, precautionary procedures must be observed when handling corrosives.

5.1. Handling of corrosive chemicals

- ✓ Appropriate PPE such as gloves, fire-resistant or all cotton lab coat, and safety goggles must be worn when working with corrosive chemicals. A face shield, rubber apron, and rubber booties may also be appropriate depending on the work performed.
- ✓ Appropriate protective gloves that are resistant to permeation or penetration from corrosive chemicals must be selected and tested for the absence of pin holes prior to use.
- ✓ Eyewashes and safety showers must be readily available in areas where corrosive chemicals are used and stored. In the event of skin or eye contact with a corrosive chemical, the affected area should be immediately flushed with water for 15 minutes. Contaminated clothing should be removed, and medical attention sought.
- ✓ Corrosive chemicals should be handled in a fume hood to ensure that any possible hazardous or noxious fumes generated are adequately vented.

- ✓ When mixing concentrated acids with water, add the acid slowly to the water. Allow the acid to run down the side of a container and mix slowly to avoid violent reactions and splattering. Never add water to acid.
- ✓ Appropriate spill clean-up material should be available in areas where corrosive chemicals are used and stored.
- ✓ Protective carriers shall be used when transporting corrosive chemicals.

5.2. Storage of corrosive chemicals

- ✓ Containers and equipment used for storage and processing of corrosive material must be corrosion resistant.
- ✓ Corrosive chemicals must be stored below eye level, preferably near the floor to minimize the danger of their falling from cabinets or shelves.
- ✓ Acids and caustics (i.e. bases) must be stored separately from each other. Secondary containers or trays must be used to separate acids and bases or other incompatible corrosives within a corrosive cabinet.
- ✓ Oxidizing acids must be separated from organic acids and flammable/combustible materials. oxidizing acids are particularly reactive with organics and flammable/combustible materials.
- ✓ Acids must be segregated from active metals, e.g., sodium, potassium, and magnesium and from chemicals that can generate toxic gases including sodium cyanide and iron sulfide.
- ✓ Corrosive gas cylinders must be returned for disposal every two years.

6. Flammable and combustible chemicals – Procedures for safe handling and storage

Chemicals which exist at ambient temperatures in a liquid form with enough vapour pressure to ignite in the presence of an ignition source are called flammable or combustible liquids. Note that the flammable/combustible liquid itself does not burn; it is the vapour from the liquid that burns. According to the National Fire Protection Association (NFPA) classification system, flammables generate sufficient vapour at temperatures below 100 ^{o}F (37.8 ^{o}C), whereas combustibles generate sufficient vapour at temperatures at or above 100 ^{o}F. Invisible vapour trails from these liquids can reach remote ignition sources causing flashback fires.

Additionally, these liquids become increasingly hazardous at elevated temperatures due to more rapid vaporization. For these reasons, precautionary measures must be observed when handling and storing flammables and combustibles.

6.1. Classification of flammable and combustible liquids

NFPA classification	Flash Point	Boiling Point
Flammable liquids		
Class IA	< 73 ^oF (22.8 ^oC)	< 100 ^oF (37.8 ^oC)
Class IB	< 73 ^oF	≥ 100 ^oF
Class IC	≥ 73 ^oF and < 10 ^oF	N/A
Combustible liquids		
Class II	≥ 100 ^oF and < 140 ^oF (60 ^oC)	N/A
Class IIIA	≥140 ^oF and < 200 ^oF (93 ^oC)	N/A

Flash point is the minimum temperature at which the liquid gives enough vapour in sufficient concentration to form an ignitable mixture in air near the surface of the liquid.

6.2. Handling of flammable and combustible chemicals

- Appropriate PPE such as gloves, fire-resistant or all cotton lab coat, and safety goggles must be worn when working with flammable/combustible liquids.
- Flammable/combustible liquids must never be heated using open flames. Preferred heat sources include steam baths, water baths, oil baths, hot air baths, and heating mantels.
- Ignition sources must be eliminated in areas where flammable vapours may be present.
- Flammable/combustible liquids should only be dispensed under a fume hood. Ventilation is one of the most effective ways to prevent the formation and concentration of flammable vapours.
- When pouring from conductive containers with a capacity of 1 gallon (3.8 litres) or greater, make sure both containers involved are electrically interconnected by bonding to each other

and to ground. The friction of flowing liquid may be sufficient to generate static electricity, which in turn may discharge, causing a spark and ignition.

- Flammable/combustible liquids in containers with a volume greater than 1 gallon (3.8 litres) should be transferred to smaller containers that can be easily manipulated by one person.
- Appropriate fire extinguishers must be available in areas where flammables are used.

6.3. Storage of flammable and combustible chemicals

- The flammable/combustible liquid in quantities exceeding a total of 10 gallons (38 litres) within a laboratory must be stored in approved flammable storage cabinets or safety cans.
- Flammable/combustible liquid stored outside of flammable storage cabinets in the laboratory should be kept to the minimum necessary for the work being done.
- Containers with a volume greater than 5 gallons (19 litres) shall not be stored in the laboratory.
- Flammable/combustible liquid stored in glass containers shall not exceed 1 gallon (3.8 litres).
- Flammable storage cabinets and safety cans must not be altered or modified.
- Safety cans with damaged screens (spark arrestors) or faulty springs (that do not close tightly) do not meet the required specifications of safety can and must be taken out of service immediately and repaired or replaced.
- Flammable liquids must only be stored in explosion-proof or laboratory-safe refrigeration equipment.
- Flammable/combustible liquid containers, filled or empty, must not be stored in hallways or obstructing exits.
- Bulk waste flammable/combustible liquids should be stored in safety cans.
- Flammables and combustibles must not be stored near oxidizers, corrosives, combustible material, or near heat sources. Make sure all chemicals stored near flammables and combustibles are compatible.

7. Oxidising agents – Procedures for handling and storage

Oxidizing agents are chemicals that bring about an oxidation reaction. The oxidizing agent may:

i. provide oxygen to the substance being oxidized, in which case the agent has to be oxygen or contain oxygen.
ii. receive electrons being transferred from the substance undergoing oxidation. Chlorine is a good oxidizing agent for electron-transfer purposes, even though it does not contain oxygen.

The intensity of the oxidation reaction depends on the oxidizing-reducing potential of the material involved. Fire or explosion is possible when strong oxidizing agents come into contact with easily oxidizable compounds, such as metals, metal hydrides or organics. Because oxidizing agents possess varying degrees of instability, they can be explosively unpredictable.

7.1.Examples of different states of oxidising agents.

Gases	Fluorine, chlorine, ozone, nitrous oxide, oxygen.
Liquids	hydrogen peroxide, nitric acid, perchloric acid, bromine, sulfuric acid.
Solids	Nitrites, nitrates, perchlorates, peroxides, chromates, dichromates, picrates, permanganates, hypochlorites, bromates, iodates, chlorites, chlorates, persulfates.

7.2. Handling of oxidising agents

- ❖ Appropriate PPE, e.g., safety goggles, gloves, fire resistant or all cotton lab coat must be worn when working with oxidizers.
- ❖ If a reaction is potentially explosive or if the reaction is unknown, use a fume hood (with the sash down as a protective barrier), safety shield, or other methods for isolating the material or the process.
- ❖ Oxidizers can react violently when in contact with incompatible materials. For this reason, know the reactivity of the material involved in an experimental process. Assure that no extraneous material is in the area where it can become involved in a reaction.

- The quantity of oxidizer used should be the minimum necessary for the procedure. Do not leave excessive amounts of an oxidizer in the vicinity of the process.

7.3. Storage of oxidising agents

- Oxidizers should be stored in a cool, dry place.
- Oxidizers must be segregated from organic material, flammables, combustibles and strong reducing agents such as zinc, alkaline metals, and formic acid.
- Oxidizing acids such as perchloric acid and nitric acid must be stored separately in compatible secondary containers away from other acids.

8. Reactive chemicals - Procedures for handling and storage

Reactives are substances that have the potential to vigorously polymerize, decompose, condense, or become self-reactive due to shock, pressure, temperature, light, or contact with another material. All reactive hazards involve the release of energy in a quantity or at a rate too great to be dissipated by the immediate environment of the reaction system so that destructive effects occur. Reactive chemicals include:

a) Explosives.
b) Organic peroxides.
c) Water-reactives.
d) Pyrophorics.

Effective control is essential to minimize the occurrence of reactive chemical hazards.

8.1. Explosive

A chemical that causes the sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden adverse conditions. Heat, light, mechanical shock, detonation, and certain catalysts can initiate explosive reactions. Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, or ozonide are sensitive to shock and heat and can explode violently.

- Appropriate PPE, e.g., face shield, safety goggles, leather outer gloves, chemical resistant gloves, fire-resistant or all cotton lab coat must be worn when working with explosives.

- Before working with explosives, understand their chemical properties, know the products of side reactions, know the incompatibility of certain chemicals, and monitor environmental catalysts such as temperature changes.
- Containers should be dated upon receipt and when opened, and expired explosives should be disposed of appropriately.
- Explosives should be kept to the minimum necessary for the procedure.
- If there is a chance of explosion, use protective barriers such as fume hood sash and a safety shield or other methods for isolating the material or process.
- Explosives should be stored in a cool, dry, and protected area. Segregate from other material that could create a serious risk to life or property should an accident occur.

8.2. Organic peroxides

These chemicals contain an -O-O- structure bonded to organic groups. These compounds can be considered as structural derivatives of hydrogen peroxide, H-O-O-H, in which one or both of the hydrogen atoms have been replaced by an organic group. Generally, organic peroxides are low-powered explosives that are sensitive to shock, sparks, and heat due to the weak -O-O- bond which can be cleaved easily. Some organic compounds such as ethers, tetrahydrofuran, and p-dioxane can react with oxygen from the air forming unstable peroxides. Peroxide formation can occur under normal storage conditions, when compounds become concentrated by evaporation, or when mixed with other compounds. These accumulated peroxides can violently explode when exposed to shock, friction, or heat.

- Appropriate PPE, e.g., safety goggles, gloves, fire- resistant or all cotton lab coat must be worn when working with organic peroxides or peroxide-forming compounds.
- Containers must be labelled with the receiving and opening dates. Discard unopened material appropriately.
- Containers should be airtight, and stored in a cool, dry place away from direct sunlight and segregated from incompatible chemicals.

- Do not refrigerate peroxide-formers, liquid peroxides, or solutions below the temperature at which the peroxide freezes or precipitates. Peroxides in these forms are extra sensitive to shock. Never store diethyl ether in a refrigerator or freezer.
- Unused peroxides should never be returned to the stock container.
- Do not use metal spatulas with peroxide-formers. Use ceramic or plastic spatulas. Contamination by metal can cause explosive decomposition.
- Avoid friction, grinding, and all forms of impact, especially with solid organic peroxides. Never use glass containers with screw cap lids or glass stoppers. Instead, use plastic bottles and sealers.
- Containers with obvious crystal formation around the lid or viscous liquid at the bottom of the container must NOT be opened or moved, they should be disposed of appropriately.
- Organic peroxides produce vapours during decomposition, this can result in pressure build-up. The rapid increase in pressure may cause explosive rupture of containers, vessels or other equipment.
- Ignition sources must be avoided.
- Organic peroxides have a self-accelerating decomposition temperature (SADT). Never store organic peroxides where they may be exposed to temperatures above the SADT. At or above this temperature an irreversible runaway reaction will take place. The recommended storage temperature is printed on the product label and SDS.

8.3. Water - reactives

A chemical that reacts with water or moisture in the air (humidity) releasing heat or flammable, toxic gas. Examples include alkali metals, alkaline earth metals, carbides, hydrides, inorganic chlorides, nitrides, peroxides, and phosphides.

- Appropriate PPE, e.g., safety goggles, gloves, fire- resistant or all cotton lab coat must be worn when working with water-reactives.
- Water-reactives should be stored under mineral oil in a cool, dry place and isolated from other chemicals.

- Water-reactives must not be stored near water, alcohols, and other compounds containing acidic OH.

In case of fire, keep water away. Appropriate fire extinguishers should be available in areas where water-reactives are used.

8.4. Pyrophorics

A chemical that ignites spontaneously in air below 130 °F (54 °C). Often the flame is invisible. Examples of pyrophoric materials include silane, silicon tetrachloride, white and yellow phosphorus, sodium, tetraethyl lead, potassium, nickel carbonyl, and caesium.

- Appropriate PPE, e.g., safety goggles, gloves, fire- resistant or all cotton lab coat must be worn when working with pyrophorics.
- Pyrophorics must be used and stored in inert environments.
- Appropriate fire extinguishers must be available in areas where pyrophorics are used.

9. Compressed Gases – Procedures for safe handling and storage

Typically, compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders must be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices must be followed when handling compressed gases because they expose workers to both chemical and physical hazards.

9.1. Handling of compressed gases

- Safety glasses with side shields or safety goggles and other appropriate PPE must be worn when working with compressed gases.
- Cylinders must be marked with a label that clearly identifies the contents.
- All cylinders must be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., must be taken out of use immediately and returned to the manufacturer/distributor for repair.

- All gas cylinders (full or empty) must be rigidly secured above the mid-line of the cylinder. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves must never be lubricated, modified, forced, or tampered. Regulator fittings must not be sealed with Teflon tape, grease or pipe sealant. Never grease any oxygen fittings, use PTFE Teflon tape only.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves must be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- Cylinders must not be placed near heat or where they can become part of an electrical circuit.
- Cylinders must not be exposed to temperatures above 50 ^{o}C (122 ^{o}F). Some rupture devices on cylinders will release at about 65 ^{o}C (149 ^{o}F). Some small cylinders are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of compressed gas must be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.
- Appropriate regulators must be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Use the Compressed Gas Association (CGA) numbered fittings appropriate for the gas in use.

Consult the manufacturer’s catalogs for the appropriate equipment. Adaptors and homemade modifications are prohibited.

- Cylinders must never be bled completely empty. Leave a slight pressure to keep contaminants out.
- Gases shall not be transferred from one compressed gas cylinder to another.

9.2. Storage of compressed gases

- When not in use, cylinders must be stored with their main valve closed and the valve safety cap in place.
- Cylinders awaiting use and empty cylinders must be stored according to their hazard classes.
- Cylinders must not be located where objects may strike or fall on them.
- Cylinders must not be stored in damp areas or near salt, corrosive chemicals, chemical vapours, heat, or direct sunlight. Cylinders stored outside must be protected from the weather.
- Corrosive gas cylinders must be returned for disposal every two years.

9.3. Special Precautions

9.3.1. Flammable Gases

- No more than two cylinders can be manifolded together; however, several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders must be shut off when the laboratory is unattended, and no experimental process is in progress.
- Flammable gas cylinders must be grounded. Do not ground to an electrical outlet.
- Flames involving a highly flammable gas must not be extinguished until the source of the gas has been safely shut off; otherwise, it can reignite causing an explosion.

9.3.2. Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a non-upright position until it has remained in an upright position for at least 30 minutes.

- The outlet line of an acetylene cylinder must be protected by a flame arrestor.
- Compatible tubing must be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

10. Cryogenic Liquids – Procedures for safe handling and storage

Cryogenic liquids are liquefied gases having boiling points of less than -73.3 °C (-100 °F). The primary hazards of cryogenic liquids include both physical hazards such as fire, explosion, and pressure build-up and health hazards such as severe frostbite and asphyxiation. Potential fire or explosion hazards exist because cryogenic liquids are capable, under the right conditions, of condensing oxygen from the atmosphere. This oxygen-rich environment in combination with flammable/combustible materials and an ignition source are particularly hazardous. Pressure is also a hazard because of the large volume expansion ratio from liquid to gas that a cryogen exhibits as it warms, and the liquid evaporates. This expansion ratio also makes cryogenic liquids more prone to splash and therefore skin and eye contact are more likely to occur. Contact with living tissue can cause frostbite or thermal burns, and prolonged contact can cause blood clots that have very serious consequences. All laboratory personnel must follow prudent safety practices when handling and storing cryogenic liquids.

10.1. Properties of common cryogenic liquids

Gas	Boiling point (ºC/ ºF)	Liquid to gas volume expansion ratio
Helium	-268.9 / -452	1 – 757
Hydrogen	-252.7 / -423	1 – 851
Nitrogen	-195.8 / -321	1 – 696
Florine	-187.0 / -307	1 – 888
Argon	-185.7 / -303	1 – 847

Oxygen	-183.0 / -297	1 – 860
Methane	-161.4 / -256	1 – 578

10.2. Handling of cryogenic liquids

- Appropriate PPE must be worn when handling cryogenic liquids. This includes special cryogen gloves, safety goggles, full face shield, impervious apron or coat, long pants, and full coverage shoes. Gloves must be impervious and sufficiently large to be readily removed should a cryogen be spilled. Watches, rings, and other jewellery should NOT be worn.
- Unprotected body parts must not come in contact with vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation is attempted.
- Objects that are in contact with cryogenic liquid must be handled with tongs or proper gloves.
- All precautions should be taken to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous.
- All equipment should be kept clean, especially when working with liquid or gaseous oxygen.
- Work areas must be well ventilated.
- Transfers or pouring of cryogenic liquid must be done very slowly to minimize boiling and splashing.
- Cryogenic liquids and dry ice used as refrigerant baths must be open to the atmosphere. They must never be in a closed system where they may develop uncontrolled or dangerously high pressure.
- Liquid hydrogen must not be transferred in an air atmosphere because oxygen from the air can condense in the liquid hydrogen presenting a possible explosion risk.

10.3. Storage of cryogenic liquids

- Cryogenic liquids must be handled and stored in containers that are designed for the pressure and temperature to which they may be subjected. The most common container for cryogenic liquids is a double-walled, evacuated container known as a Dewar flask.
- Containers and systems containing cryogenic liquids must have pressure-relief mechanisms.
- Coolers and Styrofoam boxes may be used for storage of small amounts of solid carbon dioxide (dry ice) only. Do not use coolers and Styrofoam boxes as the primary container for the transportation and storage of liquid cryogens.
- Cylinders and other pressure vessels such as Dewar flasks used for the storage of cryogenic liquids must not be filled more than 80% of capacity to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature of the cylinder may increase to above 30 ^{o}C (86 ^{o}F), a lower percentage (e.g., 60% capacity) should be the limit.
- Dewar flasks should be shielded with tape or wire mesh to minimize flying glass and fragments should implosion occur.
- Dewar flasks must be labelled with the full cryogenic liquid name and should be labelled with hazard warning information.
- Work and storage areas must be well ventilated.
- Evaporation of the liquid cryogens will displace oxygen in the room and may present an asphyxiation hazard. Air contains about 21% oxygen and breathing air with less than 19.5% is considered a dangerous oxygen deficient atmosphere. Concentrations of 18% can cause dizziness and result in unconsciousness and death.
- Do not store cryogenic Dewar’s in walk-in refrigerators. Typical walk-in refrigerators only receive fresh air when the door is opened. Evaporating liquid cryogens could displace enough air to create an oxygen deficient atmosphere.

11. Electrical safe procedure

Serious injury or death by electrocution is possible when appropriate attention is not given to the engineering and maintenance of electrical equipment and personal work practices around such equipment. In addition, equipment malfunctions can lead to electrical fires. By taking reasonable precautions, electrical hazards in the laboratory can be dramatically minimized.

- Laboratory personnel should know the location of electrical shut-off switches and/or circuit breakers in or near the laboratory so that power can be quickly terminated in the event of fire or accident.
- Electrical panels and switches must never be obstructed and should be clearly labelled to indicate what equipment or power source they control.
- All electrical equipment should be periodically inspected to ensure that cords and plugs are in good condition. Frayed wires and wires with eroded or cracked insulation must be repaired immediately, especially on electrical equipment located in wet areas such as cold rooms or near cooling baths. Insulation on wires can easily be eroded by corrosive chemicals and organic solvents.
- All electrical outlets should have a grounding connection requiring a three-pronged plug.
- All electrical equipment should have three-pronged, grounded connectors. The only exception to this rule is instruments entirely encased in plastic (such as electric pipette sand some types of microscopes) and Glas-Col heating mantels. If equipment does not have a three-pronged plug, replace the plug and cord to ground the equipment.
- Face plates must not be removed from electrical outlets.
- Electrical wires must not be used as supports.
- Extension cords should be avoided. If used, they should have three-pronged, grounded connectors, positioned or secured as not to create a tripping hazard, and ONLY for temporary use.
- All shocks must be reported to the laboratory manager. All faulty electrical equipment must be immediately removed from service until repaired.
- Electrical appliances must only be repaired by authorized electricians or the manufacturer. Unauthorized modifications of electrical appliances are strongly prohibited.

- Proper grounding and bonding of flammable liquid containers should be practised to avoid the build-up of excess static electricity. Sparks generated from static electricity are good ignition sources.
- Experimental electrical equipment in laboratories must be shielded, insulated, or have appropriate fail-safe devices when energized or in use. Personnel must be proficient in the use of the equipment and safety precautions. Personnel should be trained in first aid in case of electrical shock.

12. Glassware and sharps – Procedures for safe handling and disposal

12.1. Examples of sharps include:

* Needles
* Syringes
* Lancets
* Scalpel blades
* Exacto knives
* Broken glass
* Razo blades
* Glass Pasteur pipettes
* Microtome blades

12.2. Handling of glassware and sharps

- Glassware and sharps should be handled and stored carefully to avoid damage.
- Reusable syringes that are not biologically contaminated must be capped and put away after use. Cap syringes using the one-handed method of picking up the cap with the needle then carefully securing the cap onto the syringe. Retractable syringes are preferred. A disposable syringe should be used for biological materials and should be placed in a sharps container without recapping.
- Chipped, broken, or star-cracked glassware should be discarded or repaired. Damaged glassware should never be used unless it has been repaired.
- Because of the potential for catastrophic breakage resulting in sharp projectiles, only thick-walled, pressure-resistant glassware may be utilized under positive pressure or a vacuum.

- Use appropriate hand protection when inserting glass tubing into a rubber stopper or when placing rubber tubing on glass hose connections. Use of plastic or metal connectors should be considered.
- Use appropriate hand protection when picking up broken glass or other sharp objects. Small pieces should be swept up using a brush and dustpan.

12.3. Disposal of glassware and sharps

Sharps waste is categorized by the type of contamination present. Specific disposal methods are dictated by category, but all categories require packaging in puncture-resistant cardboard or plastic containers in order to minimize the risk of injuries.

12.3.1. Uncontaminated glassware and sharps

- Uncontaminated metals and glass sharps should be collected in a puncture-proof container, labelled, sealed and disposed of appropriately.
- Disposable items such as pipette tips and wood swabs that are not sharps but may be perforate liners of the waste receptacles present a hazard to custodians. These may be placed in any puncture resistant container such as a non-breakable plastic jar, bottle, thick plastic bag or another type of container and placed in the waste receptacle.

12.3.2. Chemically contaminated sharps

- Chemically contaminated metal or glass sharps that are grossly contaminated with hazardous chemicals should be collected in puncture-proof containers, labelled, sealed and disposed of appropriately.
- Spill residue with broken glass, spill absorbents must be collected as hazardous chemical waste and not placed into the broken glass receptacles.

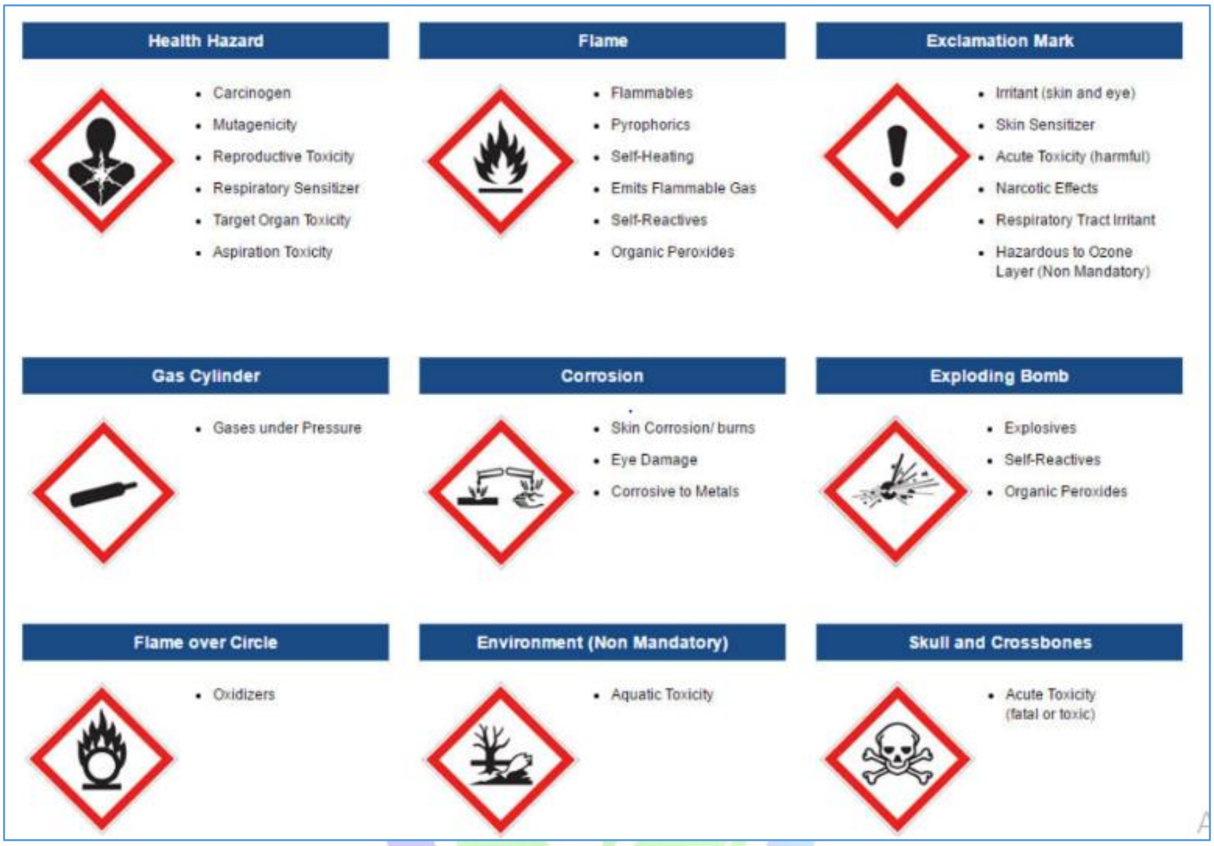
Appendix

Incident form

Incident Information		
Report any incident including injury, property damage: Immediately following the incident, email: monahengmasheane@gmail.com		
Date		
Lab Name		
Incident information		
Nature of the incident		
Date of incident		Time of the incident:
Name of Person (s) involved:		
Description of the incident:		
Action taken:		

Comments and follow up:

Hazards warning Signs



Hazardous waste list

Waste list								
Lab Name								
Staff Name						**Date**		
Cell								
Email								
#	**Item**	**Qty**	**Nature**			**State**		
			Flammable	**Corrosive**	**Toxic**	**Solid**	**Liquid**	**Other**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								

Compatibility table

Chemicals listed on the same row (Group A and Group B) are not compatible and MUST NOT be stored together in the same location.		
Group 1-A	**Group 1-B**	**Potential Consequences**
• Acetylene sludge • Alkaline caustic liquids • Alkaline cleaner • Alkaline corrosive liquids • Alkaline corrosive battery fluid • Caustic wastewater • Lime sludge & other corrosive alkalis • Lime wastewater • Lime and water • Caustic	• Acid sludge • Acid and water • Battery acid • Chemical cleaners • Electrolyte, acid • Etching acid liquid or solvent • Pickling liquor and other corrosive acids • Acid, including mixtures of acids and sulfuric acid	• Heat generation; violent reaction
Group 2-A	**Group 2-B**	**Potential Consequences**
• Aluminum • Beryllium • Calcium • Lithium • Magnesium • Potassium • Sodium • Zinc powder • Other reactive metals and metal hydrides	• Any Group 1-A or 1-B	• Fire explosion; generation of flammable hydrogen gas
Group 3-A	**Group 3-B**	**Potential Consequences**
• Alcohols • Water	• Any concentrated item from Groups 1-A or 1-B • Calcium • Lithium • Metal hydrides • Potassium • SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3 • Other water-reactives	• Fire, explosion, or heat generation; generation of flammable or toxic gases

Group 4-A	Group 4-B	Potential Consequences
• Alcohols • Aldehydes • Halogenated hydrocarbons • Nitrated hydrocarbons • Unsaturated hydrocarbons • Other reactive organic compounds and solvents	• Concentrated Group 1-A or 1- B • Group 2-A	• Fire, explosion, or violent reaction
Group 5-A	**Group 5-B**	**Potential Consequences**
• Cyanide and sulfide solutions	• Group 1-B	• Generation of toxic hydrogen cyanide or sulfide gas
Group 6-A	**Group 6-B**	**Potential Consequences**
• Chlorates • Chlorine • Chlorites • Chromic acid • Hypochlorites • Nitrates • Nitric acid, fuming • Perchlorates • Permanganates • Peroxides • Other strong oxidizers	• Acetic acid and other organic acids • Concentrated mineral acids • Group 2-A • Group 4-A • Other flammable and combustible waste	• Fire, explosion, or violent reaction