

I. SAFETY PRINCIPLES

SAFETY PRINCIPLES

1. Be prepared

- Read the safety manual.
- Undergo appropriate training.
- Gain a thorough understanding of the analysis/experiment procedure to be carried out.
- Identify possible hazards.
- Read SDS.
- Identify appropriate PPE, safety equipment and spill kits (Appendix A spill kits)

2. Minimize exposure to chemicals

- Use appropriate PPE and safety equipment.
- Minimize exposure time to hazardous substances.
- Use the smallest possible amount of chemicals.

3. Do not underestimate risks

4. Prepare for accidents

II. GENERAL SAFETY IN THE LABORATORY

DO's:

1. Read and follow the ASL Safety Guide.
2. Minimize exposure to chemicals by using PPE.
3. Observe buddy system, especially during overtime work.
4. Familiarize yourself with all potential hazards associated with the analysis/experiment.
5. Perform only authorized procedures.
6. Use only chemicals listed in authorized procedures.
7. Experiments/ Analyses must be performed only by authorized personnel.
8. Authorize only trained personnel for specific tasks.
9. Identify potential hazards in the performance of analyses/ experiments.
10. Consult the SDS regarding hazards posed by chemicals used. Work with the smallest possible quantity of chemicals to minimize waste and prevent spills.
11. Wash hands thoroughly with soap and water after working in the lab.
12. Label all containers and reagent bottles.
13. Use smallest possible quantity of chemicals.
14. Minimize chemical waste.
15. Return all Equipment, equipment accessories, glasswares and laboratory materials and chemicals to their proper places after use.
16. Clean working areas after use.
17. Clean a chemical spill promptly following the appropriate clean up protocol.
18. Properly dispose of all wastes.
19. Know the action plans in case of fire, chemical spills and other emergencies in the workplace.
20. Be aware of the voltage requirement of an equipment before plugging onto a power source.
21. Be familiarized with the emergency evacuation routes.
22. All exit routes must be conspicuous and unobstructed.
23. All safety equipment must be easily accessible.
24. Secure gas tanks and tall cabinets by chaining to walls.
25. Position storage shelves at or below eye level only.
26. Follow proper waste disposal procedures.
27. Follow proper storage of chemicals (Appendix E).
28. Clean up spills promptly.
29. Keep flammable chemicals away from heating equipment or equipment that uses fire.

DON'Ts:

1. Eating, drinking, gum-chewing, smoking and horseplay in the lab.
2. Sitting and lying on lab tables.
3. Smoking in the lab.
4. Pipetting by mouth.
5. Chemical contact on the skin and personal clothing.
6. Bringing of children and pets into the lab.
7. Playing of loud music.
8. Working alone.
9. Wearing face and eye make-up and nail polish.
10. Accessing the internet and playing computer games using computers that are coupled to lab equipment.
11. Skin contact with chemicals.
12. Storing chemicals on shelves above eye level.
13. Storing solvents in refrigerators.
14. Storing food for human consumption in laboratory refrigerators.
15. Cooking food for human consumption using laboratory heating equipment such as hot plates, ovens and furnace.
16. Using laboratory produced ice and deionized/distilled water for human consumption.
17. Ingestion of chemicals.
18. Using laboratory glassware for eating or drinking.
19. Wearing contaminated PPE outside of laboratory premises.
20. Tasting chemical substances.
21. Indiscriminately smelling of chemical substances. If you need to smell a chemical substance, do it with caution. Waft the vapor to your nose using your hand.

III. SAFETY EQUIPMENT

PERSONAL PROTECTION EQUIPMENT (PPE)

Eyewear

1. A laboratory safety eyewear must be worn in the laboratory at all times.
2. Prescription glasses installed with side shields may be used.
3. Goggles may be worn for lab work where there is a possible risk of occurrence of chemical splashes or mists.
4. Wearing of contact lenses is not allowed.
5. Sunglasses and tinted eyewear are not allowed.

Laboratory gown

1. A laboratory gown must be worn in the lab at all times.
2. Laboratory gowns must be buttoned-up.
3. Laboratory gowns used in the lab must not be worn outside lab premises, such as the office and eating areas, to avoid possible contamination of non-laboratory areas.
4. It is recommended that laboratory gowns be washed separately from common clothes.
5. Clothes that cover most parts of the body is recommended (i.e. jeans, long sleeved tops) to protect from chemical spills.
6. Sleeves must not hang loose in such a way that they may come in contact with the chemicals or equipment used.

Gloves

1. The appropriate type of gloves may be worn for hand protection from harmful chemicals (Appendix B).
2. Choose the size of gloves that is of correct fit.
3. Gloves must not be worn outside the lab to avoid the possible contamination of non-laboratory areas.

Footwear

1. Only closed-toed shoes (preferably rubber shoes with good gripping soles) are allowed when working in the lab.
2. High- heeled or stiletto shoes are not allowed.

Respirators

1. Surgical masks may be worn to filter out chemical dusts.
2. When necessary, respirators with appropriate chemicals filters may be used to protect from harmful chemical mists, dusts and vapors.

FUME HOODS

1. Substances such as acids, bases, volatile compounds, foul-odoured chemicals and chemicals that produce dusts and vapors must be handled only under the fume hood.
2. When in use, adjust the fume hood sash to the lowest possible position so as to prevent the escape of harmful chemicals. The sash would also act as barrier in the event of an accident in the hood.
3. The fume hood must not be used as a depository of chemicals.
4. Hazardous chemicals must be placed at least six inches away from the sash.
5. Never place your head inside the laboratory fume hood.
6. Never place any equipment inside the fume hood, unless otherwise authorized by the lab manager.
7. The fume hood's working surface, walls and sash must be kept clean.
8. Fume hoods must be tested at least once annually for efficiency.
9. A fume hood that is not suitable for laboratory work must be appropriately and conspicuously labeled "NOT WORKING".
10. A fume hood that is incompatible to certain chemicals must bear the proper warning signage.
11. The sash must be fully closed when the fume hood is not in use.
12. Check the airflow for the following:
 - Airflow into the hood is not affected by cross drafts
 - Airflow into the hood follows a uniform inward pattern.
 - Average velocity of airflow into the hood is within acceptable limits.

FIRE EXTINGUISHERS

1. Fire extinguishers of the Type ABC are strategically placed in the laboratory. (Refer to Appendix C for different types of fire extinguishers and their suitability).
2. Type ABC extinguishers can be used to extinguish fire of the following nature: burning paper or wood, flammable liquids, flammable gases and electrical contact.
3. A fire extinguisher may only be operated by skilled and trained personnel.
4. A fire extinguisher may only be used to put out small fires.
5. Keep record of inspection and maintenance of fire extinguishers.
6. Refer to SOP SM002 for inspection and maintenance of fire extinguishers.
7. Sand, which is useful for Class D fires involving metals, can also be used for all types of fire.

SAFETY SHOWER AND EYE WASH

1. All personnel must be knowledgeable on the proper use of the safety shower and eye wash.
2. A safety shower and eye wash are situated in a well conspicuous area in the laboratory.
3. Each personnel must familiarize himself on the location and the proper use of the safety shower and eye wash.
4. Do not use the lab shower to flush the eye. The high pressure of the water coming from the shower may injure the delicate areas of the eye.
5. Always ensure the unobstructed access to the shower and eye wash.
6. The safety shower and eye wash must not be used for ordinary bathing or any other purposes.
7. Observe proper maintenance of lab shower and eye wash stations (SOP SM001).

IV. EMERGENCIES AND ACTION PLANS

CHEMICAL SPILL ON PERSONNEL

Chemical contact on a small portion of the skin:

1. Identify the chemical involved.
2. Identify the body area involved.
3. Flush the affected area with clean running water for 15 minutes or more.
4. Remove affected clothing or jewelry.
5. Evaluate affected area for burn or injury.
6. If there are visible burn or injury, seek medical attention immediately.
7. If there is no burn or injury, wash affected area with soap and water.
8. Do not apply any cream, lotion or medication to affected area without medical advice.
9. Dispose of contaminated clothing according to waste disposal procedures.
10. Consult the SDS for information regarding possible delayed effects of the contaminant on the body.
11. Prepare an incident report.

Chemical contact on a large area of the skin or body:

1. If possible call for help so that others may assist you in your emergency.
2. Identify the chemical involved.
3. Identify the body area involved.
4. Using the safety shower, flush the affected area with clean running water for 15 minutes.
5. Carefully remove affected clothing and jewelry. Avoid transfer of chemical to the eyes and face.
6. Evaluate affected area for burn or injury.
7. If there are visible burns or injury, seek medical attention immediately.
8. If there is no burn or injury, wash with soap and water.
9. Do not apply any cream, lotion or medication to affected area without medical advice.
10. Dispose of contaminated clothing according to waste disposal procedures.
11. Consult the SDS regarding possible delayed effects of the contaminant on the body.

Chemical contact on the eyes:

1. If possible, call for help so that your co-workers may assist you in dealing with your emergency situation.
2. Identify the chemical involved.
3. Flush the affected eye with clean water using an emergency eyewash for at least 15 minutes.
4. While flushing the eye, hold the eyelids open and move the eyeballs vertically and horizontally to wash most parts of the eye.
5. In the absence of an emergency eye wash, clean water may be poured onto the affected eye while the worker is lying on his back.
6. Do not use the safety shower to flush the eyes. High water pressure from the safety shower may injure the delicate parts of the eyes.
7. Do not apply any medication on the affected eye(s).
8. Seek immediate medical evaluation and attention.
9. Consult the SDS on possible delayed effects of the chemical.

Inhalation of toxic chemical fumes:

1. Evacuate the contaminated area.
2. Bring affected personnel to well-ventilated area.
3. Consult SDS.
4. Seek medical attention immediately.

Ingestion of chemicals:

1. Seek immediate medical attention.
2. Consult SDS.
3. Do not induce vomiting.

CHEMICAL SPILL ON WORK AREAS:

Chemical spill of low flammability (inorganic acids and bases; excluding hydrofluoric acid):

1. Identify the chemical involved in the spill.
2. Isolate the affected area.
3. Evacuate the affected area if necessary.
4. Inform co-workers in the nearby work areas that may be affected by the spill.
5. Use appropriate PPE.
6. Neutralize acid/base using the following:

Clean-up Material	Use
Sodium bisulfite	Neutralize alkali
Sodium carbonate or bicarbonate	Neutralize acids

7. Absorb neutralized acid/base using sand.
8. Using plastic dustpan and scoop, transfer contaminated sand in polyethylene container with lid.
9. Follow appropriate waste disposal protocol for contaminated sand.

Chemical spill of flammable solvents:

1. Flammable solvents include petroleum ether, hexane, pentane, diethyl ether, dimethoxyethane and tetrahydrofuran. The person who caused the spill is responsible in its clean up.
2. Identify the chemical involved in the spill.
3. Isolate the affected area.
4. Evacuate the affected area.
5. Put off flames and turn off spark- producing equipment.
6. If necessary, turn off power.
7. Use appropriate PPE.
8. Refer to SDS.
9. Absorb spilled solvent using sand.
10. Using plastic dustpan and scoop, transfer contaminated adsorbent to a polypropylene container with lid.
11. Follow proper disposal protocol.

Spill involving highly toxic substance:

1. Do not attempt to clean up highly toxic substance.
2. Isolate the affected area.
3. Evacuate the affected area.
4. Inform the Pollution Control Officer and Safety officer immediately.

Bromine spill:

1. Isolate the affected area.
2. Evacuate the affected area if necessary.
3. Inform co-workers in the nearby work areas that may be affected by the spill.
4. Use appropriate PPE.
5. Neutralize spill with 5% sodium thiosulfate solution.
6. Absorb neutralized spill with sand.
7. Using plastic dustpan and scoop, transfer contaminated sand into polyethylene container with lid.
8. Follow appropriate disposal protocol for contaminated sand.

Hydrofluoric acid spill in the fume hood:

1. Do not use water to wash spill.
2. Isolate the affected area.
3. Evacuate the affected area if necessary.
4. Inform co-workers in the nearby work areas that may be affected by the spill.
5. Use appropriate PPE.
6. Neutralize spill with soda ash or lime.
7. Absorb neutralized spill with sand.
8. Using plastic dustpan and scoop, transfer contaminated sand into polyethylene container with lid.
9. Follow appropriate disposal protocol for contaminated sand.

Hydrofluoric acid spill outside of the fume hood:

1. Do not use water to wash spill.
2. Isolate the affected area.
3. Evacuate the affected area if necessary.
4. Inform co-workers in the nearby work areas that may be affected by the spill.
5. Call the Pollution Officer for assistance.

Alkali metals spill (lithium, sodium, magnesium, potassium):

1. Identify the chemical involved in the spill.
2. Isolate the affected area.
3. Evacuate the affected area if necessary.
4. Inform co-workers in the nearby work areas that may be affected by the spill.
5. Use appropriate PPE.
6. Avoid contact with water.
7. Smother with dry sand.
8. Using plastic dustpan and scoop, transfer contaminated dry sand to polyethylene container with lid.
9. Follow appropriate disposal protocol of contaminated sand.

Mercury spill:

1. Isolate the affected area.
2. Evacuate the affected area.
3. Inform co-workers in the nearby work areas that may be affected by the spill.
4. Use appropriate PPE.
5. Do not wash with water.
6. Use special mercury spill kit.
7. Using aspirator bulb, collect mercury beads and store in sealed polyethylene container.
8. For mercury in solution, apply mercury decontaminating powder.
9. Using a mop/rag, collect neutralized solution.
10. Store contaminated mop/rag in sealed polyethylene container.
11. Follow appropriate disposal protocol of contaminated mop/rag.

FIRE

What to do:

Implement the 3A's in the following order :

1. Activate the alarm system and notify the fire department.
2. Assist those who are in danger but ensure personal safety as well.
3. Attempt to put out the fire – only when one is trained to do so and when personal safety is not at risk.

Remember:

1. Personnel is not obliged to put out a fire in his workplace.
2. Only trained personnel may use a fire extinguisher to put out a fire.
3. During an attempt to put out a fire, keep the exit at your back, in case you need to escape.
4. Do not attempt to put out a fire where there is heavy smoke that may be toxic, and affect walking speeds and visibility distance.
5. Fire extinguishers may be used to put out only a small fire which is around the size of a small waste bin.
6. Always remember that a small fire can rapidly become a big fire.
7. Familiarize yourself with the different types of and uses of available fire extinguishers available in the workplace (Appendix C).

How to use the fire extinguisher:

P**Pull** the Pin.

A**Aim** extinguisher nozzle at the base of the flames.

S**Squeeze** trigger while holding the extinguisher upright.

S**Sweep** the extinguisher from side to side, covering the area of the fire with the extinguishing agent.

ACCIDENT INVOLVING ELECTRICITY

Electrocution:

1. Immediately turn off the power source. Do not have physical contact with affected person unless the power source has been cut off.
2. Immediately transport personnel for medical evaluation and treatment of burns and injury.

FALLS

1. Immediately examine the affected personnel for physical injury.
2. Do not move injured person who is suspected to have sustained a fracture. Wait for emergency medical team (EMT) to evaluate and transport personnel to medical facility.
3. Keep the injured person conscious while waiting for the EMT to arrive.

CUTS

Minor cut:

1. Make sure that the area of the cut is free of glass shards.
2. If there are glass shards on the wound, bring personnel to medical facility for treatment of wound.
3. If the wound has been evaluated to be free of glass shards, apply first aid treatment.
4. Stop the bleeding by applying pressure on and elevating the affected area.
5. Clean affected area with soap and water.
6. Apply antibacterial cream on affected area. (Caution: iodine or hydrogen peroxide may cause skin irritation).
7. Cover with bandage or sterile dressing.
8. Change the dressing at least once a day.
9. Where there is sign of infection, seek immediate medical attention.

Major cut:

1. Make sure that the cut is free of glass shards.
2. If there are glass shards, cover the affected area with loose sterile cloth and elevate the wounded area to slow the bleeding. Do not apply pressure on the wound.
3. If there are no glass shards, cover the affected area with loose sterile cloth, apply pressure on the wound and elevate the wounded area to slow the bleeding.
4. Immediately bring personnel to medical facility for treatment.
5. Patient may need tetanus shot if the wound is caused by dirty or rusty objects.

EARTHQUAKE

When indoors:

1. **DROP**
 - Drop to your hands and knees and steadily crawl to seek cover
2. **COVER –**
 - In a crouching position, find cover under a solid furniture such as tables and desks
 - Cover your head and neck with one hand and arm to protect from falling objects and debris.
3. **HOLD ON**
 - Using the other hand, hold on to the furniture covering you so that it does not move during the shaking.
4. When the shaking stops, find the nearest exit and proceed to the **IC evacuation area**.
5. Examine yourself for physical injuries and seek first aid treatment.
6. Be ready for aftershocks.
7. Wait for further instructions from the ASL Safety Officer.

When outdoors:

1. Stay outdoors and seek an open space.
2. Stay away from objects that may fall such as trees, lamp posts, walls, glass windows, etc.
3. During strong shaking, do not run, assume a crouching position and protect your head and torso with your hands.
4. When the shaking stops, proceed to the **IC evacuation area**.
5. Examine yourself for physical injuries and seek first aid treatment.
6. Be ready for aftershocks.
7. Wait for further instructions from the ASL Safety Officer.

IC Evacuation Area:

The designated IC Evacuation area are CS amphitheater seats that are nearest to the IC teaching building.

V. HAZARDOUS SUBSTANCES

A hazardous substance is defined as “a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees.” (OSHA Laboratory Standard (29 CFR 1910.1450)).

Most chemicals used in our experiments and analysis may be toxic, corrosive or flammable, posing significant hazard to the worker and the environment.

It is important that the worker is knowledgeable on the hazard of handling and exposure to different chemicals and the use of appropriate safety equipment.

As a general rule, *“treat all compounds as potentially harmful, especially new and unfamiliar materials, and work with them under conditions to minimize exposure by skin contact and inhalation.”*

Hazardous substances (Appendix D) may be classified as follows:

CARCINOGENS

Carcinogens are chemical and physical agents that cause cancer. They are considered chronic toxins – after repeated and long-duration exposure, their effect may manifest after a long latency.

REPRODUCTIVE TOXINS

Reproductive toxins are substances that may affect the development and growth of an unborn fetus. Their effect may manifest years after one has been repeatedly exposed.

CORROSIVE SUBSTANCES

Corrosive substances cause tissue damage on the site of chemical contact. These include strong acids, dehydrating agents and oxidizing agents.

IRRITANTS

Irritants are non-corrosive substances that may cause reversible inflammation of the tissue on the site of chemical contact.

TOXIC AGENTS

Toxic agents are substances which may cause lethal effect when ingested, inhaled or absorbed through the skin.

SENSITIZERS

Sensitizers, also known as allergens, cause allergic reaction after repeated exposure or exposure to high dose of the substance.

FLAMMABLE AND EXPLOSIVE SUBSTANCES

Flammable and explosive substance are materials that decompose upon explosive to mechanical shock, elevated temperature or chemical action, resulting to the release of heat (causing fire) and gas (causing explosion).

VI. WORK SPECIFIC PRECAUTIONS

FOURIER-TRANSFORM INFRARED SPECTROSCOPY

Hazard Source	Hazard and Precautions
Handling of powder/ fine materials	<ul style="list-style-type: none">• Air blown from air conditioning units may blow away powder samples, contaminate the FTIR room and cause their inhalation by workers in the room.
Use of KRS-5	<ul style="list-style-type: none">• KRS-5 is toxic and must be handled with care.
Hydraulic Press	<ul style="list-style-type: none">• Read the operation manual before use.• Operate the hydraulic press within its pressure limit.• Use only specified/ recommended pellet molds.
He-Ne laser	<ul style="list-style-type: none">• Do not stare into the laser beam or at its bright reflection to avoid eye injury.
Use of Purge gas	<ul style="list-style-type: none">• Do not use flammable gas for purging the spectrometer. Heat from the laser and light source may ignite the flammable purge gas.
Use of volatile solvents, toxic and malodorous materials	<ul style="list-style-type: none">• Handle volatile, malodorous and harmful materials and solvents in the fume hood.• Ensure proper ventilation in the FTIR room.• Do not place volatile solvents near the equipment.• Do not place sample holders with volatile solvents in the sample compartment longer than necessary.• Use the smallest possible quantity of volatile solvents.• Handle volatile, toxic and malodorous substances under the fume hood.
Use of halogenated compounds	<ul style="list-style-type: none">• Chlorinated solvents, perfluorinated solvents and halogenated hydrocarbons may be pyrolyzed when exposed to IR and laser heat and producing toxic compounds including hydrochloric acid (HCl), hydrofluoric acid (HF) and phosgene (COCl₂).

HIGH PRESSURE LIQUID CHROMATOGRAPHY

Hazard Source	Hazard and Precautions
High Pressure	<ul style="list-style-type: none">• Solvent leaks from high pressure lines of the HPLC system and the degassing apparatus may cause eye injuries
Use of Solvents	<ul style="list-style-type: none">• Mobile phase solutions may involve be toxic, volatile and malodorous solvents. Handle with appropriate PPE and safety equipment• Store mobile phase solutions and wastes in narrow-necked screw-capped bottles with punched holes to accommodate solvent lines.• Excess solvent must be stored in the chemical storage room• Avoid skin contact• Avoid prolonged exposure to vapours• Leak accumulation in closed space such as heated column oven may cause explosion of flammable solvent• Consider chemical compatibility of solvents and their appropriate waste handling and storage• Read SDS
Use of toxic reagents and standards	<ul style="list-style-type: none">• Read SDS
Use of syringe for manual injection	<ul style="list-style-type: none">• Care must be taken to avoid injury due to syringe needle tips and sharps from broken syringe.
Column oven	<ul style="list-style-type: none">• Column oven and its content may be set at high temperature that may cause burns upon skin contact
Lamps in detectors	<ul style="list-style-type: none">• Avoid eye exposure to detector light source such as deuterium, tungsten and xenon lamps

UV-Vis AND FLUORESCENCE SPECTROMETRY

Hazard Source	Hazard and Precautions
Light source	<ul style="list-style-type: none">• Avoid eye exposure to light source such as deuterium, tungsten and xenon lamps
Use of solvents	<ul style="list-style-type: none">• Use appropriate PPE and safety equipment.• Keep room well ventilated.• Do not keep samples holder (such as cuvettes) containing volatile, toxic and malodorous solvents in the sample compartment for a much longer time than necessary.• Risk of ignition of flammable solvents.• Avoid skin and eye contact.

GAS CHROMATOGRAPHY

Hazard Source	Hazard and Precautions
GC parts at high temperature	<ul style="list-style-type: none">• During operation, many parts of the GC may reach high temperature that can cause burns upon skin contact: injection port column oven column detector and detector vent Column nuts and tubing from the column to the injection port and detector Valve box Column oven vent
Hydrogen gas	<ul style="list-style-type: none">• Hydrogen, commonly used as fuel in flame ionization detector, is potentially explosive.• Hydrogen is combustible over a wide range of concentrations. At atmospheric pressure, hydrogen is combustible at concentrations from 4% to 74.2% by volume.• Hydrogen has the highest burning velocity of any gas.• Hydrogen has a very low ignition energy.• Hydrogen that is allowed to expand rapidly from high pressure into the atmosphere can self-ignite due to an electrostatic spark.• Hydrogen burns with a nonluminous flame which can be invisible under bright light• Hydrogen leak from the GC or source tank may cause buildup in the system or the room, leading to explosion.• Hydrogen can accumulate in the GC system and cause explosion.• Turn off hydrogen supply immediately in the event of emergency shutdown of GC• Never vent hydrogen from a high pressure cylinder directly to atmosphere. Self-ignition may occur.• Do not measure hydrogen with air or oxygen to avoid ignition.• Measure gas flows separately.• Turn off ignitor when measuring hydrogen flow.

GAS CHROMATOGRAPHY (continued):

Hazard Source	Hazard and Precautions
Refractory ceramic fiber	<ul style="list-style-type: none">• The injection ports, detector port and valve box are insulated by materials using refractory ceramic fibers which is harmful on inhalation and skin contact.
Use of syringe	<ul style="list-style-type: none">• Care must be taken to avoid injury due to syringe needle tips and sharps from broken syringe.
Use of toxic reagents and standards	<ul style="list-style-type: none">• Some reagents and standards may be toxic.• Use PPE and safety equipment.• Consult SDS

FLAME ATOMIC ABSORPTION SPECTROMETRY WITH AIR-ACETYLENE FLAME

Hazard Source	Hazard and Precautions
Acetylene	<ul style="list-style-type: none">• Highly flammable. Can form explosive acetylides.• Incompatible with copper, silver, mercury, chlorine gas and grease.• Incompatible with copper tubing or brass with >65% copper• Do not run acetylene at >105 kPa (15 psi)
Air-acetylene flame	<ul style="list-style-type: none">• Air-acetylene flame may reach 2000°C or above.• Air-acetylene flame emits UV radiation.• Always put the flame shield in place during operation.• Never leave the air-acetylene flame unattended.
Hot surfaces	<ul style="list-style-type: none">• Burner heads and flame shields become hot from the air-acetylene flame that may cause burn injuries.
Acetylene gas cylinders	<ul style="list-style-type: none">• Acetylene gas cylinders may topple. It must be secured to the wall with a chain. Gas cylinders may leak and saturate the room with flammable gas.
Use of acids and bases	<ul style="list-style-type: none">• Acid digestion procedures may cause spills that may cause accidental skin and eye contact with sample, acid or base that may cause injuries.• Corrosive materials such as acids and bases (may cause eye, skin and respiratory injuries.• The burning of acidic and basic solutions of samples in the air-acetylene flame emits corrosive and toxic fumes and vapors.• Nitric or perchloric acid residues are not compatible with solvent residues.• Use appropriate PPE.• Maintain adequate ventilation and removal of fumes using efficient exhaust systems.

FLAME ATOMIC ABSORPTION SPECTROMETRY WITH AIR-ACETYLENE FLAME
(continued):

Hazard Source	Hazard and Precautions
Toxic gas, fumes, vapors	<ul style="list-style-type: none">• Produced by burning acidic, basic and organic solutions of samples in the air-acetylene flame.• Always turn on the exhaust systems during operation of the AAS.• Use PPE.
Use of hollow cathode and deuterium lamps	<ul style="list-style-type: none">• Hollow cathode lamps and deuterium lamps emit UV radiation which may cause eye injury when viewed directly.• Do not stare directly into the beam.• Lamps may break and shards may cause cuts.• Hollow cathode lamps are under negative pressure, thus the risk of implosion when improperly disposed.• Hollow cathode lamps produce heat, which may cause burns when improperly handled.
Clogged burner head	<ul style="list-style-type: none">• Can cause flame back-flash with explosive and fire hazard.• Ensure liquid trap is filled to the correct level.
Use of organic solvents and standards	<ul style="list-style-type: none">• Some organic solvents may be incompatible with air acetylene flame or may produce toxic fumes upon burning.• Do not use organic solvent with specific gravity of less than 0.75.• Do not allow the accumulation of large volume of waste solvent from the spray chamber in the waste vessel. Empty the waste vessel frequently to a storage solvent waste vessel located in a well-ventilated area.• Never use glass bottles as waste vessel.• Prepare organic solvents and standards in a separate room away from the AAS working area to minimize fire hazard.• Never aspirate chlorinated hydrocarbons such as chloroform or carbon tetrachloride since they will readily decompose in the flame to produce phosgene-an extremely hazardous compound.• Gasoline, carbon-disulfide and tetrahydrofuran (THF) must not be aspirated directly as these have very low flash points and can create an extreme fire hazard.

CIRCULAR DICHROISM-OPTICAL ROTATORY DISPERSION SPECTROSCOPY:

Hazard Source	Hazard and Precautions
High voltage power source	<ul style="list-style-type: none">• Risk of electric shock.• Operate equipment only with the covers closed.
Xenon light source	<ul style="list-style-type: none">• Produces intense ultraviolet radiation that is harmful to the eyes and skin.• Do not stare directly into the beam.• Do not open the xenon casing when the lamp is turned on.
Electromagnet	<ul style="list-style-type: none">• Produces heat; thus requiring water cooling system.• Failure of water cooling system may accumulate much heat, that may lead to burn hazard, shorting of its electrical system and even fire.• Exposure to very high levels electromagnetic radiation. can be harmful to health.
Nitrogen purge gas	<ul style="list-style-type: none">• Nitrogen cylinder may leak and introduce high concentration of nitrogen into the atmosphere making it oxygen deficient, which may be an asphyxiation hazard..
Production of Ozone	<ul style="list-style-type: none">• Ozone, generated by the xenon lamp, is a respiratory health hazard.• Ensure efficient N₂ gas purge• Keep room well ventilated.

SAMPLE PREPARATION:

Hazard Source	Hazard and Precautions
Use of acids and bases	<ul style="list-style-type: none">• Corrosive• May cause skin, eye and respiratory irritation and injury• Produces harmful fumes when heated.• May cause accidental spill to the eye and skin during digestion.• Obtain safety information and exercise utmost safety precaution on the use of perchloric and hydrofluoric acids.• Use PPE and safety equipment
Use of glasswares	<ul style="list-style-type: none">• Glassware may break and shards may cause cuts
Use of heating apparatus	<ul style="list-style-type: none">• Heating apparatus such as hot plate, oven, furnace and incubator, and thermostatic baths may operate at high temperature and may cause skin burns when accidentally handled improperly.• Heat from heating apparatus may ignite flammable solvents stored nearby.• Samples heated at high temperature may cause toxic fumes.• Glasswares may break with extreme heat, causing spillage of their contents.• Do not heat capped glasswares.• Use proper handling apparatus.
Use of electric powered apparatus	<ul style="list-style-type: none">• Risk of electrocution when improperly handled.• May cause fire when improperly plugged to incompatible power input.• Do not overload power outlets.
Liquid spills on floors	<ul style="list-style-type: none">• May cause fall injuries.• Clean up spills immediately
Obstruction of exit and entry access	<ul style="list-style-type: none">• May cause fall injuries• Remove objects that may cause obstruction to entry and exit ways
Use of flammable solvents	<ul style="list-style-type: none">• Fire hazard• Store in designated cabinets• Use minimally.
Use of toxic reagents and solvents	<ul style="list-style-type: none">• Health hazard• Use appropriate PPE and safety equipment.• Consult SDS
Objects stored on high shelves	<ul style="list-style-type: none">• Objects may fall during earthquake• Do not store reagents above eye level.• Anchor cabinets and gas tanks to walls.

SAMPLE PREPARATION (continued):

Waste material	<ul style="list-style-type: none">• Waste materials such as solvent, acid and basic waste may accumulate and emit harmful fumes• Segregate reagent waste properly, taking in consideration their chemical compatibilities.
Unlabelled containers	<ul style="list-style-type: none">• Cast doubt on the identity, storage, use and disposal of their contents.
Water Deionizer/distillation system	<ul style="list-style-type: none">• The water boiling vessel is heated to high temperature, posing burn injuries upon accidental skin contact.
Centrifuge	<ul style="list-style-type: none">• Unbalanced centrifuge tubes may cause the machine to wobble and lead to mechanical failure that can cause chemical spillage, and harm to the personnel and the workplace.• Centrifugation of solutions may cause harmful aerosols.• Always balance the position of centrifuge tubes• Avoid overloading centrifuge tubes.• Keep area well ventilated• Use PPE
Use of rotary evaporation	<ul style="list-style-type: none">• Hot surfaces of thermostatic bath• Escape of solvent vapors from the distillation system• Solvent spill• Flammable solvents• Glassware breakage due to stuck joints and vacuum
titration	<ul style="list-style-type: none">• Chemical spill to the skin and eyes when agitating solution during titration• Generation of toxic vapors produced from chemical reaction of titrant and sample

VII. APPENDICES

APPENDIX A – SPILL KITS

The laboratory spill kit must include the following items:

1. Personal Protective Equipment (PPE)

- Goggles and face shield
- Neoprene gloves
- Disposable laboratory gowns and apron for corrosive material
- Plastic vinyl boots
- Dust mask and respirators

2. Neutralizers

- Acid neutralizer: sodium bicarbonate, sodium carbonate, or calcium carbonate.
- Base neutralizer: sodium bisulfate.
- Bromine neutralizer: 5% sodium thiosulfate
- Hydrofluoric acid: soda ash or lime

3. Absorbents

- Universal spill adsorbent:
1:1:1 mixture of unscented kitty litter, sodium bicarbonate and sand.
- Sand
- Dry sand for alkali metals and acid chlorides.

4. Clean-up equipment

- Plastic dustpan and scoop
- XL garbage bags for contaminated PPE
- 5 gal polyethylene container with lid

5. Others

- Mercury spill kit: aspirator bulb, decontaminating powder
- HF acid antidote: calcium gluconate

APPENDIX B – GLOVE SELECTION GUIDE*







Glove type	Use	Advantage	Disadvantage
Latex (natural rubber)	Biological hazards	Excellent tensile strength and elasticity	Can cause allergic reactions
Butyl	Peroxide, strong acids and bases, alcohols, aldehydes, ketones and esters	Protects against a wide variety of chemicals	Do not use with aliphatic and aromatic hydrocarbons and halogenated solvents
Neoprene	Alcohols, oxidizing acids, hydraulic fluids, phenols, glycol ethers	Good pliability, finger dexterity, high density and tear resistance	Poor for halogenated and aromatic hydrocarbons
Nitrile	Oils, grease, aliphatic chemicals, xylene, alcohols, acids and caustics	Good dexterity and sensitivity	Poor against strong oxidizing agents, benzene, methylene chloride, phenol, ketones, acetates and aromatic solvents
Polyvinyl chloride (PVC)	Strong acids and bases, salts, and other water solutions	Can be used for immersion, less dexterity and sensitivity	Plasticizers can be stripped, poor tear resistance
Cryogenic gloves	Cryogenics	Protects against tissue damage from cryogenics or very cold containers and equipment	Not for immersion
Leather	Welding, sheet metal work, handling hot or cold objects, gardening	Provides protection against heat, cold, sparks and cuts, they come in a wide variety of styles and fit	Not for working with liquids and when wet will offer poor protection against heat and cold
Kevlar fibre	Work where temperature extremes are an issue	Protects against tear, abrasion and cutting	Thicker gloves can impede movement

APPENDIX B – GLOVE SELECTION GUIDE (continued):

Glove type	Use	Advantage	Disadvantage
Mesh	Used for work that requires repeated cutting and slicing	Protects against cutting and slicing	Steel mesh gloves can be heavy and impede movement
Aluminised	Furnace work, handling hot objects	Provides good protection against heat	Not to be used for electrical work
Cotton	General duty work	Moderate resistance to heat and cold	May need to be thicker to offer full protection.

*Selection and use of gloves guidelines, SAFE@WORK by University of Wollongong, Australia. (<https://smah.uow.edu.au/content/groups/public/@web/@ohs/documents/doc/uow136685.pdf>)

APPENDIX C – CLASS OF FIRE AND TYPES OF FIRE EXTINGUISHERS*

CLASS	A	B	B	C	D	K
PICTURE SYMBOL						
TYPE	Common Combustibles Solids (wood, paper, cloth, etc.)	Flammable liquids Gasoline and solvents	Flammable gases Propane	Live electrical equipment Computers, fax machines	Combustible Metals Magnesium, Lithium, Titanium	Cooking Media Cooking oils and fats
Water	✓ Yes	✗ No	✗ No	✗ No	✗ No	✗ No
Foam	✓ Yes	✓ Yes	✗ No	✗ No	✗ No	✓ Yes <small>(ABF Foam Only)</small>
Dry Powder	✓ Yes	✓ Yes	✓ Yes	✓ Yes	✗ No	✗ No
M28/L2	✗ No	✗ No	✗ No	✗ No	✓ Yes	✗ No
Carbon Dioxide CO ₂	✗ No	✓ Yes	✗ No	✓ Yes	✗ No	✗ No
Wet Chemical	✓ Yes	✗ No	✗ No	✗ No	✗ No	✓ Yes

*Source: <http://www.totalfireandsafety.com/blog/283/>

APPENDIX D – HAZARDOUS SUBSTANCES

1. Carcinogenic compounds:

Alkylating agents (a-halo ethers)	bis(chloromethyl) ether methyl chloromethyl ether
Alkylating agents (sulfonates)	1,4-butanediol dimethanesulfonate Diethyl sulfate Dimethyl sulfate Ethyl methanesulfonate Methyl methanesulfonate Methyltrifluoromethanesulfonate 1,3-propanesulfonate
Alkylating agents (epoxides)	Ethylene oxide Diepoxybutane Epichlorhydrin Propylene oxide
Alkylating agents (aziridines)	Ethylenimine 2-methylaziridine
Alkylating agents (diazo, azo, and azoxy compounds)	4-dimethylaminoazobenzene
Alkylating agents (electrophilic akenes and alkynes)	Acrylonitrile Acrolein Ethyl acrylate
Acyating agents	B-propiolacetone Dimethylcarbamoyl chloride
Organohalogen compounds	1,2-dibromo-3-chloropropane Mustard gas (bis(2-chloroethyl)sulfide) Vinyl chloride Carbon tetrachloride Chloroform 3-chloro-2-methyl propene 1,2-dibromomethane 1,4-dichlorobenzene 1,2-dichloroethane 2,2-dichloroethane 1,3-dichloropropene Hexachlorobenzene Methyl iodide Tetrachloroethylene Trichloroethylene 2,4,6-trichlorophenol

Carcinogenic Compounds (continued):

Hydrazines	Hydrazine (and hydrazine salts) 1,2-diethylhydrazine 1,1-dimethylhydrazine 1,2-dimethylhydrazine
N-nitroso compounds	N-nitrosodimethylamine N-nitroso-N-alkylureas
Aromatic amines	4-aminobiphenyl Benzidine (p,p'-diaminobiphenyl) α-naphthylamine aniline o-anisidine (2-methoxyaniline) 2,4-diaminotoluene o-toluidine
Aromatic hydrocarbons	Benzene Benz[a]anthracene Benzo[a]pyrene
Natural products (including antitumor drugs)	Adiamycin Aflatoxin Bleomycin Cisplatin Progesterone Reserpine Safrole
Miscellaneous organic compounds	Formaldehyde (gas) Acetaldehyde 1,4-dioxane Ethyl carbamate (urethane) Hexamethylphosphoramide 2-nitropropane Styrene Thiourea, thioacetamide
Miscellaneous inorganic compounds	Arsenic and certain arsenic compounds Chromium and certain chromium compounds Thorium dioxide Beryllium and certain beryllium compounds Cadmium and certain cadmium compounds Lead and certain lead compounds Nickel and certain nickel compounds Selenium sulfide

Select Carcinogens:

2-acetylaminofluorene Acrylonitrile 4-aminobiphenyl Amalgestic mixture containing phenacetin Arsenic and some arsenic compounds Asbestos Benzene Benzidine Betel quid containing tobacco Bis(chloromethyl) ether 1,4-butanediol dimethylsulfonate Chlorambucil Chloromethyl methyl ether Chromium and certain chromium compounds Coal-tar pitches Coal tar Conjugated estrogens 1,2-dibromo-3-chloropropane 3,3'-dichlorobenzidine (and its salts) Vinyl chloride	Dimethylaminoazobenzene Ethylene oxide Ethylenimine Formaldehyde Melphalan Methoxsalen with ultraviolet A azathioprine 4,4'-methylene-bis(2-chloroaniline) Mustard gas α -naphthylamine B-naphthylamine 4-nitrobiphenyl N-nitrosodimethylamine B-propiolactone Shale oils Smokeless tobacco products Soot and soot extracts Thorium oxide Tobacco smoke treoculphan
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2. Reproductive Toxins:

Acrylic acid Aniline Cadmium Benzene Carbon disulfide N,N-dimethylacetamide Dimethylformamide Dimethylsulfoxide Diphenylamine Estradiol Formaldehyde formamide	Hexachlorobenzene Iodoacetic acid Lead compounds Mercury compounds Nitrobenzene Nitrous oxide Phenol Polychlorinated compounds polybrominated compounds biphenyls toluene vinyl chloride xylene
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3. Corrosive substances:

Strong acids	Sulfuric acid Nitric acid Hydrochloric acid Hydrofluoric acid
Dehydrating agents	Sulfuric acid Sodium hydroxide Phosphorous pentoxide Calcium oxide
Oxidizing agents	Hydrogen peroxide Chlorine bromine

4. Toxic agents

Toxins with specific organ targets:

Target organ	Toxic substances
Liver (hepatotoxin)	Nitrosamines Carbon tetrachloride
Kidney (nephrotoxin)	Halogenated hydrocarbons
Nervous system (neurotoxin)	Mercury Acrylamide Carbon disulfide
Hematopietic system	Carbon monoxide Cyanides
Lung	Asbestos silica

Lethal Dose:

Route	Toxic (LD ₅₀)	Highly toxic (LD ₅₀)
Oral	50 – 500 mg/kg	Less than 50 mg/kg
Skin contact	200-1000 mg/kg	Less than 200 mg/kg
Inhalation	200-2000 ppm	Less than 200 ppm

5. Sensitizers:

Diazomethane Chromium Nickel Formaldehyde Isocyanates	arylhydrazines Benzylic halides Allylic halides Phenol derivatives
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6. Flammable and Explosive and Potentially Explosive Substances:

<p>Substances with low flash point* (<i>in parenthesis</i>)</p> <p><i>*Flashpoint is the lowest temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.</i></p>	<p>Acetone (-17.8 °C) Benzene (-11.1 °C) Carbon disulfide (-30.0 °C) Cyclohexane (-20.0 °C) Diethyl ether (-45.0 °C) Ethanol (12.8 °C) Hexane (-21.7 °C) Methanol (11.1 °C) Pentane (-40.0 °C) Toluene (4.4 °C)</p>
Acetylinic compounds	<ul style="list-style-type: none"> Explosive in mixtures of 2.5-80% air
Aluminum chloride	<ul style="list-style-type: none"> With moisture, may generate sufficient HCl, causing pressure buildup.
Ammonia	<ul style="list-style-type: none"> With iodine, produces nitrogen triiodide (explosive) Produces violent reaction with organic halides under heat and pressure.
Azides	<ul style="list-style-type: none"> Forms highly explosive organic polyazides with chlorinated hydrocarbons
Dry benzoyl peroxide	<ul style="list-style-type: none"> Easily ignited, sensitive to shock
Carbon disulfide	<ul style="list-style-type: none"> Very flammable
Chlorine	<ul style="list-style-type: none"> Violent reaction with hydrogen or hydrocarbons
Diazomethane	<ul style="list-style-type: none"> Its pure gas and liquid readily explodes
Dimethyl sulfoxide	<ul style="list-style-type: none"> Explosive in contact with metal hydrides and active halogen compounds
Diethyl, diisopropyl and other ethers	<ul style="list-style-type: none"> Explosive in the presence of peroxides
Ethylene oxide	<ul style="list-style-type: none"> Explosive when heated in a closed container.
Halogenated compounds	<ul style="list-style-type: none"> Violent reaction with sodium, potassium and other active metals
Hydrogen peroxide	<ul style="list-style-type: none"> 30% hydrogen peroxide reacts violently with iron, copper, chromium, other metals and their salts.

Flammable and Explosive and Potentially Explosive Substances (continued):

Lithium aluminum hydride	<ul style="list-style-type: none">• Flammable in combination with ethyl ether and tetrahydrofuran.
Oxygen tanks	<ul style="list-style-type: none">• Explosive in contact with oil
Ozone	<ul style="list-style-type: none">• Explosive (in liquid and solid form)
Catalysts	<ul style="list-style-type: none">• Palladium, platinum on carbon, platinum oxide, Raney nickel• Very reactive; spontaneously flammable on exposure to air.
Perchlorates	<ul style="list-style-type: none">• Explosive with organic compounds
Permanganates	<ul style="list-style-type: none">• Explosive when treated with sulfuric acid
Inorganic peroxides	<ul style="list-style-type: none">• Peroxides of barium, sodium and potassium explodes and ignites with combustible materials
Red and white phosphorous	<ul style="list-style-type: none">• Forms explosive mixtures with oxidizing agents.
Phosphorous trichloride	<ul style="list-style-type: none">• Decomposes upon reaction with water forming phosphine which is explosive and flammable.
Potassium	<ul style="list-style-type: none">• Ignites upon exposure to humid air.
Sodium	<ul style="list-style-type: none">• Reacts violently with water

APPENDIX E – INCOMPATIBLE CHEMICALS

Chemical	Incompatible substance
Acetic acid	Chromic acid Nitric acid Perchloric acid Peroxides Permanganates
Acetylene	Chlorine Bromine Copper Fluorine Silver Mercury
Acetone	Concentrated nitric acid Sulfuric acid mixtures
Alkali and alkaline earth metals	Water Carbon tetrachloride Chlorinated hydrocarbons Carbon dioxide Halogens
Ammonia (anhydrous)	Mercury Chlorine Calcium hypochlorite Iodine Bromine Hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids Powdered metals Flammable liquids Chlorates Nitrites Sulfur Finely divided organic or combustible material
Aniline	Nitric acid Hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Bromine	Ammonia Acetylene Butadiene Butane Methane Propane (other petroleum gases) Hydrogen Sodium carbide Benzene Finely divided metals Turpentine
Calcium oxide	Water
Activated carbon	Calcium hypochlorite All oxidizing agents

Incompatible chemicals (continued):

Chemical	Incompatible substance
Carbon tetrachloride	Sodium
Chlorate	Ammonium salts Acids Powdered metals Sulfur Finely divided organic or combustible materials
Chromic acid and chromium	Acetic acid Naphthalene Camphor Glycerol Trioxide alcohol Flammable liquids in general
Chlorine	Ammonia Acetylene Butadiene Butane Methane Propane (other petroleum gases) Hydrogen Sodium carbide Benzene Finely divided metals Turpentine
Chlorine dioxide	Ammonia Methane Phosphine Hydrogen sulfide
Copper	Acetylene Hydrogen peroxide
Cumene hydroperoxide	Acids (inorganic or organic)
Cyanides	Acids
Decaborane	Carbon tetrachloride Other halogenated hydrocarbons
Flammable liquids	Ammonium nitrate Chromic acid Hydrogen peroxide Nitric acid Sodium peroxide Halogens
Fluorine	Everything
Hydrocarbons	Fluorine Chlorine Bromine Chromic acid Sodium peroxide
Hydrocyanic acid	Nitric acid alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)

Incompatible chemicals (continued):

Chemical	Incompatible substance
Hydrogen peroxide	Copper Chromium Iron Most metals and their salts Alcohols Acetone Organic materials Aniline Nitromethane Combustible materials
Hydrogen sulfide	Fuming nitric acid Oxidizing base
Hypochlorites	Acids Activated carbon
Iodine	Acetylene Ammonia (aqueous and anhydrous) Hydrogen
Mercury	Acetylene Fulminic acid Ammonia
Nitrates	Sulfuric acid
Nitric acid, concentrated	Acetic acid Aniline Chromic acid Hydrocyanic acid Hydrogen sulfide Flammable liquids Flammable gases Copper Brass Any heavy metal
Nitrites	Acids
Nitroparaffins	Inorganic base Amines
Oxalic acid	Silver Mercury
Oxygen	Oils Grease Hydrogen Flammable liquid Flammable solid Flammable gas
Perchloric acid	Acetic anhydride Bismuth and its alloys Alcohol Paper Wood Grease Oils

Incompatible chemicals (continued):

Chemical	Incompatible substance
Peroxides, organic	Acids (organic or mineral) Friction Note: store cold
Phosphorous (white)	Air Oxygen Alkalis Reducing agents
Potassium	Carbon tetrachloride Carbon dioxide Water
Potassium chlorate	Sulfuric acid Other acids
Potassium perchlorate	Sulfuric acid Other acids Ammonium salts Acids Powdered metals Sulfur Finely divided organic or combustible materials
Potassium permanganate	Glycerol Ethylene glycol Benzaldehyde Sulfuric acid
Selenides	Reducing agents
Silver	Acetylene Oxalic acid Tartaric acid Ammonium compounds Fulminic acid
Sodium	Carbon tetrachloride Carbon dioxide Water
Sodium nitrate	Ammonium nitrate Other ammonium salts
Sodium peroxide	Ethyl alcohol Methyl alcohol Glacial acetic acid Acetic anhydride Benzaldehyde Carbon disulfide Glycerin Ethylene glycol Ethyl acetate Methyl acetate Furfural
Sulfides	Acids

Incompatible chemicals (continued):

Sulfuric acid	Potassium chlorate Potassium perchlorate Potassium permanganate Compounds of light metals such as sodium and lithium
Tellurides	Reducing agents

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