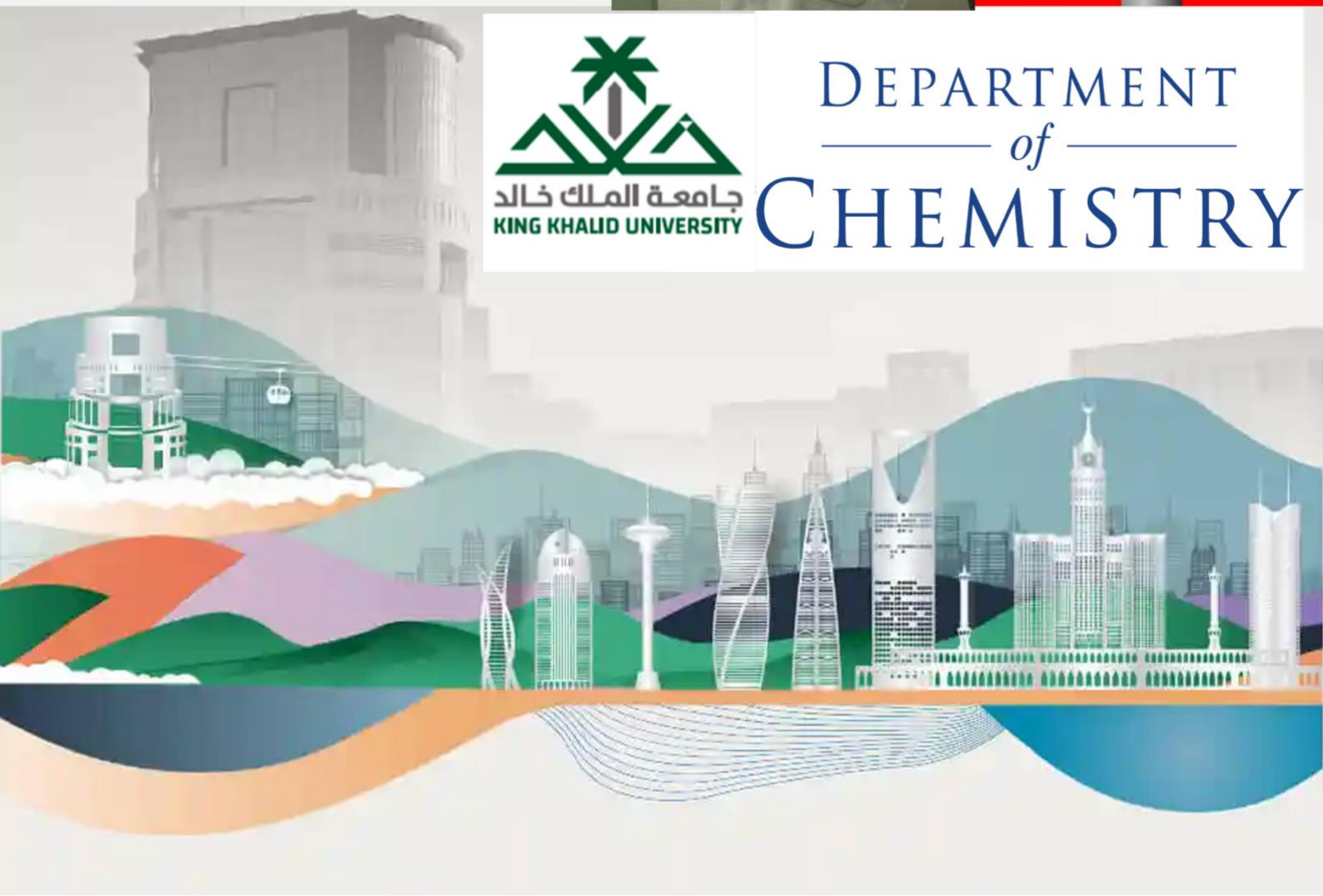
Safety Manual



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KING KHALID UNIVERSITY

DEPARTMENT *of* CHEMISTRY

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جامعة الملك خالد
KING KHALID UNIVERSITY

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كلية العلوم
قسم الكيمياء

SAFETY MANUAL

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Table of Contents

1. Objectives of the Manual

- To establish a culture of safety in laboratories, classrooms, and research facilities.
- To provide clear guidance on safe laboratory practices and emergency procedures.
- To minimize environmental impacts by adopting conservation practices.
- To ensure hazardous waste is managed, treated, and disposed of safely and legally.
- To protect the health and safety of students, staff, researchers, and the public.

2. Essential Laboratory Regulations

Personal Conduct

- Every individual in the laboratory must always behave responsibly and professionally.
- Running, horseplay, or careless behavior is strictly prohibited.
- Distractions, loud conversations, and the use of mobile devices are discouraged, as they can compromise both safety and concentration.
- Eating, drinking, chewing gum, or applying cosmetics in the laboratory is forbidden, since food and personal items can easily become contaminated with hazardous substances.

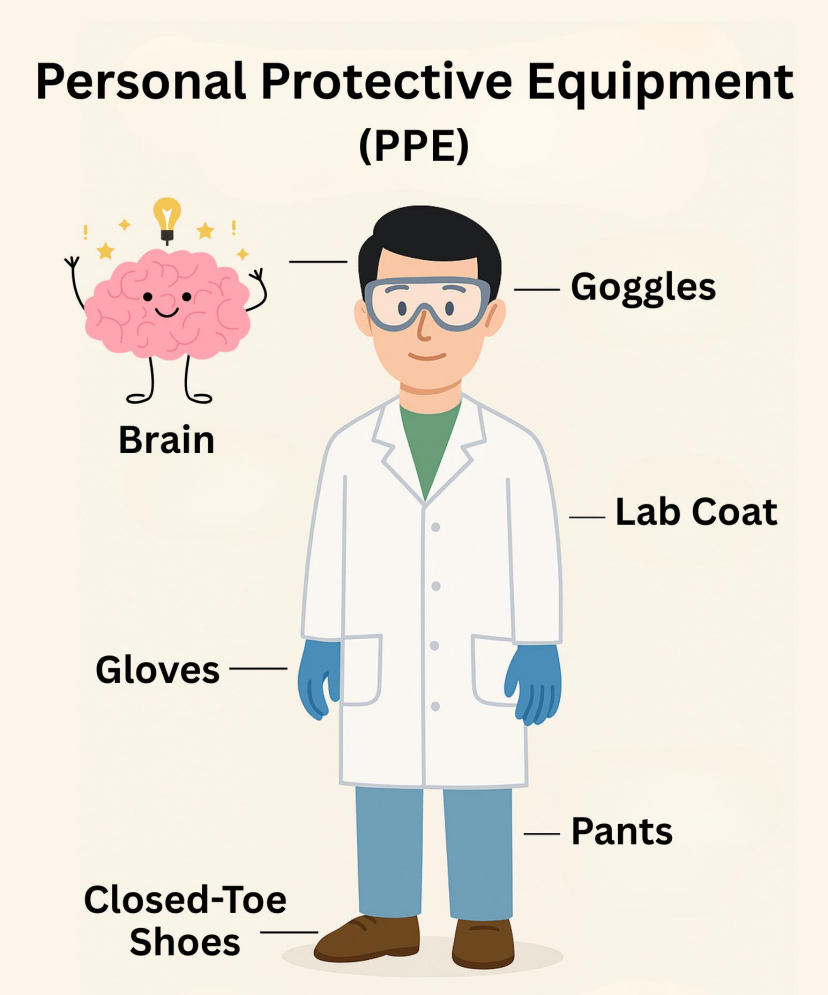
Dress Code and Personal Protective Equipment (PPE)

- Proper attire is essential for safe laboratory work.
- Laboratory coats must be always worn to protect against spills and splashes.
- Closed-toe shoes are mandatory, and sandals, slippers, or open footwear are not permitted.
- Long hair should be tied back securely to avoid contact with flames, chemicals, or moving equipment. Safety goggles or protective glasses must be worn whenever chemicals are handled, and additional PPE such as gloves, face shields, or aprons should be used as appropriate to the task.

Preparation Before Entering the Laboratory

- Students and researchers are expected to come prepared by reading experimental procedures beforehand. Unfamiliar experiments or equipment must not be attempted without proper instruction from the instructor or supervisor.

- Individuals must also know the location of emergency equipment, including fire extinguishers, safety showers, eyewash stations, and first aid kits, before starting any laboratory work.



3. Handling of Chemicals and Equipment

- All chemicals must be treated with respect, regardless of their perceived level of danger.
- Labels on containers should always be read carefully before use, and no chemicals are to be transferred into unmarked containers.
- Equipment must be handled properly, and damaged or malfunctioning instruments should be reported immediately.
- Students must never attempt unauthorized modifications or repairs to laboratory apparatus.

Housekeeping and Laboratory Cleanliness

- Maintaining a clean and organized workspace is a critical safety practice.
- Workbenches should remain free of unnecessary items, and spills should be cleaned immediately using appropriate spill-control methods.
- All chemical containers must be tightly closed after use, and waste should be disposed of in designated containers according to proper waste disposal protocols.
- Before leaving the laboratory, glassware should be washed, equipment returned to its storage area, and the workspace left in an orderly condition.

Disposal

- Chemicals must never be poured down sinks or drains unless explicitly authorized by the supervisor. Separate waste containers are provided for organic solvents, aqueous waste, broken glass, and solid chemical waste.
- It is the responsibility of each laboratory user to ensure proper segregation of waste materials. Incompatible chemicals should never be mixed, and containers should always remain labeled.

Emergency Preparedness

- All individuals must be aware of the emergency exit routes and procedures for fire, chemical spills, or medical emergencies.
- In case of an accident, the incident must be reported immediately to the instructor or supervisor, regardless of its severity.
- Prompt reporting ensures that proper measures are taken and similar incidents can be prevented in the future.

Record Keeping and Documentation

- Accurate and complete recording of experimental details is a professional and safety requirement. Laboratory notebooks should include observations, quantities of chemicals used, safety concerns, and any deviations from standard procedures.
- Proper documentation helps in reproducing results, understanding errors, and ensuring compliance with laboratory standards.

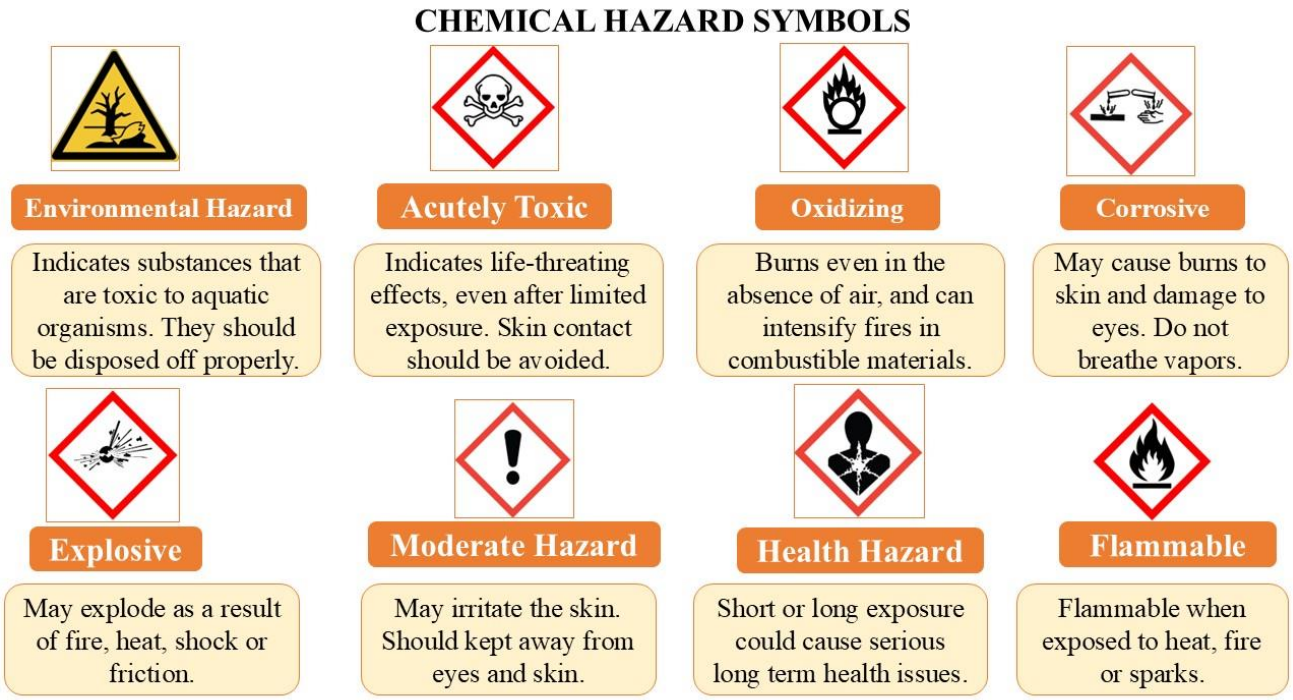
4. Health and Safety Hazards in the Laboratory

Chemical Hazards

- Chemicals such as strong acids, bases, solvents, oxidizers, flammable liquids, and toxic gases pose serious risks in the laboratory.
- They can cause burns, poisoning, respiratory irritation, fires, or explosions.
- To prevent accidents, all chemicals must be properly labeled, handled with care, stored according to compatibility, and used with appropriate personal protective equipment such as gloves, goggles, and laboratory coats.
- Fume hoods should always be used when handling volatile or hazardous chemicals.

Chemical Hazard Symbols

Chemical hazard symbols are found on bottles of chemical reagents in the lab. Here, we took a look at European hazard symbols and the various dangers that they warn of.



Physical Hazards

- Laboratory activities often involve heat sources like Bunsen burners and hot plates, as well as UV lamps, lasers, noise, and pressure vessels. These hazards can result in burns, eye damage, hearing loss, or explosions if not managed carefully. Preventive measures include the use of

heat-resistant gloves, protective face shields, hearing protection, and regular inspection of equipment before use.

Biological Hazards

- Experiments that involve bacteria, fungi, blood samples, or plant and animal tissues can introduce biological risks. These hazards may cause infections, allergic reactions, or cross-contamination.
- To reduce these risks, biological materials must be handled under biosafety conditions, sterilization methods should be followed, biological waste must be disposed of properly, and vaccinations should be kept up to date where necessary.

Mechanical Hazards

- Mechanical hazards arise from laboratory equipment such as centrifuges, glassware, sharp instruments, and moving machinery.
- These can cause cuts, punctures, crush injuries, or accidents from broken glass.
- Preventive measures include careful handling of glassware, proper training in the use of machinery, use of safety guards and shields, and reporting damaged equipment immediately.

Electrical Hazards

- Electrical equipment in the laboratory can pose risks if it has faulty wiring, overloaded circuits, or exposed cables. These hazards can result in electric shocks, fires, or burns.
- To ensure safety, all electrical devices must be regularly inspected, hands must remain dry when handling electrical equipment, water must be kept away from circuits, and only grounded plugs should be used.

Fire and Explosion Hazards

- Flammable solvents, compressed gases, and reactive chemicals can create conditions for fires and explosions in the laboratory.
- These incidents can cause severe burns and significant damage.
- Preventive measures include storing flammable substances properly, keeping fire extinguishers easily accessible, avoiding open flames near volatile substances, and ensuring good ventilation.

Radiation Hazards

- Laboratories that use radioactive isotopes or X-ray equipment pose the risk of radiation exposure. Such exposure can damage DNA, increase cancer risk, or cause radiation sickness.
- To minimize danger, radiation must be handled with strict compliance to regulations, using lead shielding, dosimeters, and restricted access areas.

Ergonomic Hazards

- Improper workstation setup, repetitive pipetting, and heavy lifting can lead to ergonomic hazards in the laboratory.
- These hazards may result in musculoskeletal strain, back pain, or fatigue.
- Preventive measures include maintaining correct posture, using ergonomically designed laboratory equipment, taking frequent breaks, and practicing safe lifting techniques.

Waste Hazards

- Improper disposal of chemicals, sharps, or contaminated materials can cause injuries, environmental pollution, or long-term health risks.
- To avoid such hazards, waste must always be segregated into proper containers, clearly labeled, and disposed of according to hazardous waste disposal protocols.

Psychological Hazards

- Laboratory work can also involve psychological stress, especially from long hours, strict deadlines, or pressure to achieve results.
- Stress and fatigue can reduce concentration and increase the likelihood of accidents.
- Preventive measures include proper workload management, regular breaks, supportive supervision, and awareness of mental health and well-being.

Electrical Safety

- Electricity is widely used in the chemistry laboratory to power instruments, heating devices, lighting, and other essential equipment.
- While it is indispensable for modern laboratory work, electricity poses significant hazards if not handled correctly.

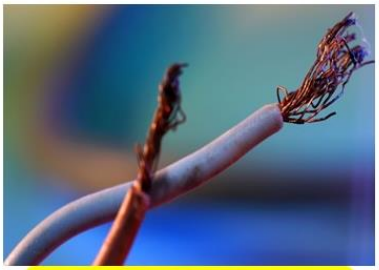
- Risks include electric shock, burns, short circuits, equipment damage, and even laboratory fires. Therefore, strict adherence to electrical safety protocols is essential for protecting both personnel and equipment.

5. Inspection of Electrical Equipment

- All electrical equipment, including hot plates, centrifuges, and analytical instruments, must be inspected regularly for damage.
- Frayed wires, loose plugs, exposed conductors, or broken insulation should never be ignored. Any faulty equipment must be reported immediately and taken out of service until repaired by qualified personnel.

Electrical hazards to Avoid

Overloaded circuits



Frayed Wiring

Tangled Cords

Splash Hazards

Overloaded circuits

Overloaded circuits

Proper Use of Electrical Devices

- Laboratory personnel must never attempt to modify or repair electrical devices unless specifically trained and authorized to do so.
- Equipment should only be used for its intended purpose and in accordance with the manufacturer's instructions.

- ❖ Overloading power outlets or extension cords must be strictly avoided, as this can cause overheating and fire hazards.

Handling with Dry Hands

- ❖ Contact with electrical equipment must always be made with dry hands.
- ❖ Working with wet hands or near wet surfaces increases the risk of electric shock.
- ❖ Water, solvents, and other liquids must be kept away from electrical devices, and spills must be cleaned immediately before continuing work.

Grounding of Equipment

- ❖ Electrical equipment must be properly grounded to prevent the buildup of static electricity and reduce the risk of shock.
- ❖ Only grounded plugs and sockets should be used. Double-check that grounding wires are intact before operating high-voltage devices.

Safe Operation Practices

- ❖ Power switches should always be turned off before plugging in or unplugging any device.
- ❖ Equipment should not be left running unattended unless it is specifically designed for continuous operation.
- ❖ High-voltage instruments such as electrophoresis units or X-ray generators should only be operated by trained personnel under supervision.

Emergency Procedures

- ❖ In the event of an electrical accident, the power supply must be switched off immediately before attempting to help the victim.
- ❖ Direct contact with an electrocuted person should be avoided until the power is disconnected, as this could transfer the current.
- ❖ All electrical accidents, regardless of severity, must be reported promptly to the laboratory supervisor and recorded for safety audits.

Training and Awareness

- ❖ All laboratory users must receive training in basic electrical safety before operating laboratory instruments.

- ❖ They should be familiar with the location of circuit breakers, emergency shut-off switches, and fire extinguishers.
- ❖ Awareness of proper practices reduces risks and helps maintain a safe environment.

6. Environmental Conservation Standards

Resource Conservation

- ❖ Energy consumption should be minimized by switching off unused equipment, lights, and computers.
- ❖ Laboratories and offices should adopt energy-efficient lighting and ventilation systems.
- ❖ Water should be conserved through low-flow fixtures and responsible usage during experiments.

Pollution Prevention

- ❖ All chemical reactions should be planned to minimize emissions of toxic gases and particulates.
- ❖ Fume hoods must be used for experiments involving volatile substances or toxic vapors.
- ❖ Routine air quality monitoring should be carried out in laboratories and waste storage areas.

Sustainable Practices

- ❖ Preference should be given to non-toxic, biodegradable, and renewable materials wherever possible.
- ❖ Paper usage should be reduced through electronic documentation and double-sided printing.
- ❖ Recycling bins should be available for paper, glass, metals, and plastics across the facility.

Fire Safety

- ❖ Fire hazards are a major concern in the chemistry laboratory due to the frequent use of flammable solvents, combustible materials, reactive chemicals, and ignition sources such as Bunsen burners, hot plates, and electrical equipment.
- ❖ A lack of vigilance can quickly result in accidents leading to burns, property damage, or even life-threatening situations.
- ❖ Fire safety is therefore an essential part of laboratory practice, and every individual working in the laboratory must be aware of preventive measures, safe handling procedures, and emergency responses.

Awareness of Fire Hazards

- Laboratory personnel must recognize that solvents such as ethanol, methanol, ether, acetone, and toluene are highly flammable.
- Compressed gases, reactive chemicals, and oxidizers can also intensify fire risks.
- Open flames should never be used in areas where flammable vapors are present.

Proper Storage of Flammable Materials

- Flammable liquids must always be stored in approved, flame-resistant cabinets and kept in tightly sealed containers.
- Only the minimum quantity required for an experiment should be taken into the working area. Containers of incompatible chemicals, such as oxidizers and fuels, must be stored separately to prevent dangerous reactions.

Safe Work Practices

- Open flames, hot surfaces, and electrical sparks should be carefully controlled and kept away from volatile materials.
- Heating of flammable solvents should always be done with water baths, heating mantles, or other indirect heating devices instead of open flames.
- Good housekeeping practices, such as cleaning spills immediately and keeping work areas uncluttered, are critical in preventing fire accidents.

Fire Protection Equipment

- Every laboratory must be equipped with accessible fire extinguishers, fire blankets, sand buckets, and fire alarms.
- Laboratory users should be trained in the proper use of different classes of fire extinguishers (Class A for solids, Class B for liquids, Class C for electrical fires, etc.).
- Safety showers and eyewash stations should also be functional in case of fire-related accidents.

Emergency Response in Case of Fire

- If a small fire occurs, it may be controlled using the appropriate extinguisher, fire blanket, or sand, but only if it can be done safely.
- If a fire grows beyond control, individuals must immediately activate the fire alarm, evacuate the laboratory, and notify emergency services.

- ❖ Personal safety must always take priority over saving equipment or experiments.

Evacuation Procedures

- ❖ Laboratory personnel must know the location of emergency exits and evacuation routes.
- ❖ During an evacuation, elevators should not be used, and individuals should move quickly but calmly to designated assembly points outside the building.
- ❖ Attendance must be taken to ensure no one is left behind.

Training and Preparedness

- ❖ Fire drills should be conducted regularly to familiarize laboratory personnel with evacuation procedures and fire response strategies.
- ❖ New students and researchers must be given fire safety training before starting laboratory work. Maintaining awareness and preparedness greatly reduces the likelihood of fire accidents and ensures an effective response in case of emergency.

7. Fire Extinguishers:

Fire, depending on its origin, is classified as:

- Class A: Combustible materials: Wood, paper, furniture etc.
- Class B: Flammable Liquids
- Class C: Flammable Gas
- Class D: Metal Fire
- Class E: Electrical equipment
- Class K: Oil, greases

IF FIRE OCCURS

Stay Calm and Assess the Situation

- ❖ Do not panic. Quickly determine the size and location of the fire to decide whether it can be safely controlled or whether immediate evacuation is necessary.

Raise the Alarm

- ❖ Activate the nearest fire alarm switch and immediately notify everyone in the laboratory and nearby rooms. Inform the laboratory supervisor or safety officer without delay.

Use Fire Extinguishers or Fire Blankets (If Safe)

- If the fire is small and manageable, attempt to extinguish it using the appropriate fire extinguisher or a fire blanket. Always ensure that you are positioned with a clear escape route behind you before attempting to fight the fire.

Shut Down Equipment and Remove Ignition Sources

- Turn off electrical equipment, gas supplies, and heating devices if it can be done safely. This reduces the risk of the fire spreading further.

Evacuate Immediately if Fire Cannot Be Controlled

- If the fire is too large, do not attempt to fight it. Leave the laboratory at once, close the doors behind you to contain the fire, and proceed quickly but calmly to the designated emergency exit.

Assist Others and Avoid Elevators

- Help colleagues or students evacuate, if necessary, but do not put yourself at risk. Elevators must not be used during fire emergencies; always use the stairs.

Go to the Assembly Point

- Move to the designated safe assembly area outside the building. Do not re-enter the laboratory or building until emergency services have declared it safe.

Report to Authorities

- Once outside, provide details to emergency responders, including the location of the fire, the chemicals involved (if known), and whether anyone remains inside the building.

Hazardous Waste Defined

- A hazardous waste is a waste that causes, or significantly contributes to, an increase in mortality or an increase in serious, irreversible or incapacitating illness; or poses a substantial present or potential hazard to human health or the environment when it is improperly treated, stored, transported, disposed of or otherwise managed.

8. Listed Hazardous Waste

- Hazardous wastes are classified by regulatory agencies such as the U.S. Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA) into four main categories of listed wastes.

- These lists identify specific wastes from industries and laboratories that are considered hazardous because of their chemical composition, toxicity, or harmful effects.

Essential components of RCRA Regulation

F-List (Wastes from Non-Specific Sources)

- These are wastes generated from common industrial and laboratory processes, regardless of the industry.
- Spent solvents (e.g., methylene chloride, trichloroethylene, toluene, xylene, acetone).
- Wastewater treatment sludges from electroplating and metal finishing operations.
- Spent halogenated and non-halogenated solvent mixtures used in cleaning or degreasing.
- Laboratory cleaning solvents and degreasing agents.

K-List (Wastes from Specific Sources)

These are wastes tied to specific industries or production processes.

- Wastewater treatment sludges from the production of pesticides.
- Residues from petroleum refining, chemical manufacturing, or metal smelting.
- Still bottoms from organic chemical manufacturing.
- Wastes from explosives or munitions manufacturing.

P-List (Acutely Hazardous Wastes)

These are unused commercial chemical products that are extremely toxic and can cause severe harm in small quantities.

- Cyanide compounds
- Arsenic trioxide
- Phosgene
- Nicotine and salts
- Aldrin and Dieldrin (pesticides)

U-List (Toxic Wastes)

These are unused commercial chemical products that are hazardous but less acutely toxic than the P-list.

- Acetone
- Benzene
- Phenol
- Formaldehyde
- Mercury-containing compounds

Universal Wastes (Special Category)

These are widely produced hazardous wastes that are managed under streamlined rules.

- Batteries (lead-acid, nickel-cadmium, lithium-ion).
- Pesticides.
- Mercury-containing equipment (thermometers, manometers, fluorescent lamps).
- Certain electronic wastes (circuit boards, cathode ray tubes).

9. Hazardous Waste Characteristics

Hazardous waste is defined not only by its source or listing but also by its inherent physical and chemical properties. The U.S. Environmental Protection Agency (EPA) and other international agencies identify four primary hazardous waste characteristics:

Ignitability

A solid waste that has any of the following properties displays the characteristic of ignitability and is considered a hazardous waste:

- A liquid, other than an aqueous solution containing less than 24 percent alcohol by volume, with a flash point below 60ºC (140ºF).
- A non-liquid, capable under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes, and when ignited burns so vigorously and persistently that it creates a hazard.
- An ignitable compressed gas, which includes gases that form flammable mixtures at a concentration of 13 percent or less in air.
- An oxidizer, such as permanganate, inorganic peroxide, or nitrate that readily stimulates combustion of organic materials.

Corrosivity

A solid waste that has any of the following properties displays the characteristic of corrosivity and is considered a hazardous waste:

- Is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, using EPA-specified or approved test methods.
- Is a liquid and corrodes steel at a rate greater than 6.35 mm (0.25 inch) per year at a test temperature of 55ºC (130º F).

Reactivity

A solid waste that has any of the following properties displays the characteristic of reactivity and is considered a hazardous waste:

- Is normally unstable and readily undergoes violent change without detonation
- Reacts violently with water.
- Forms potentially explosive mixtures with water.
- When mixed with water generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
- Is a cyanide or sulfide bearing waste that generates toxic gases, vapors, or fumes when exposed to pH conditions between 2 and 12.5.
- Is capable of detonation or explosive reaction when subject to a strong initiating source or if heated in confinement.

- Is readily capable of detonation, explosive decomposition, or reaction at standard temperature and pressure.

Toxicity

- A waste is toxic if it leaches harmful substances into groundwater or soil. A waste which, when using the toxicity characteristic leaching procedure (TCLP), leaches any number of metallic, organic, or pesticide constituents in concentrations greater than specified in the regulation.
- Examples of these constituents include arsenic, barium, cadmium, chloroform, chromium, m-cresol, mercury, selenium, and silver.
- Disposal of hazardous materials into sinks, drains, commodes, or other sewage disposal channels is STRICTLY PROHIBITED**.**

Table 1: Hazardous Waste Characteristics

Characteristic	Definition	Examples	Main Hazard
Ignitability	Easily flammable (flash point < 60 °C)	Acetone, gasoline, ethanol	Fire, explosion
Corrosivity	Strong acids/bases (pH ≤ 2 or ≥ 12.5)	HCl, H_2SO_4, NaOH	Corrosion, burns
Reactivity	Unstable, explosive, or toxic gas release	Sodium metal, picric acid, cyanides	Explosion, toxic gases
Toxicity	Releases harmful substances into environment	Lead, mercury, pesticides	Poisoning, contamination

10. Hazardous Waste Determination

- Hazardous waste determination is the process of evaluating whether a material meets the legal definition of hazardous waste under regulatory standards such as the Resource Conservation and Recovery Act (RCRA) and related environmental laws.
- Proper determination is essential for ensuring compliance, preventing environmental pollution, and protecting human health.
- A proper Hazardous Waste Determination starts with determining whether a material is a waste. A waste is generally defined as a material which is intended to be discarded.
- This includes materials that are spent or that are “inherently waste-like”, i.e. compromised the containers integrity or exhibit characteristics including rust, crystallization, etc.

- ❖ Materials that are being used for their intended purpose or are otherwise still reusable are not considered waste. A waste can be a solid, liquid, semisolid or contained gaseous material.
- ❖ After determining that your material is a waste, those responsible for generating the waste must determine if the waste is a hazardous waste.
- ❖ Hazardous waste cannot be disposed of by pouring down a drain or by discarding in the general trash. There are significant fines and penalties involved when hazardous waste is disposed of illegally.
- ❖ In addition to the regulatory concerns, hazardous wastes disposed down the sink or in the trash may cause environmental harm and can also create an unacceptable risk to human health.

Step 1: Is the material a solid waste?

- ❖ A material is considered a solid waste if it is discarded by being abandoned, recycled, or inherently waste-like.
- ❖ Solid waste includes solids, liquids, gases, and sludges.

Step 2: Is the solid waste excluded?

- ❖ Certain wastes are specifically excluded from hazardous waste regulation (e.g., household waste, agricultural waste, domestic sewage, irrigation return flows).
- ❖ If the waste is excluded, it is not regulated as hazardous waste.

Step 3: Is the waste listed?

- ❖ Check if the waste is on one of the EPA hazardous waste lists:

F-list: Non-specific sources.

K-list: Source-specific wastes.

P-list/U-list: Discarded commercial chemical products.

- ❖ If listed, the waste is automatically hazardous.

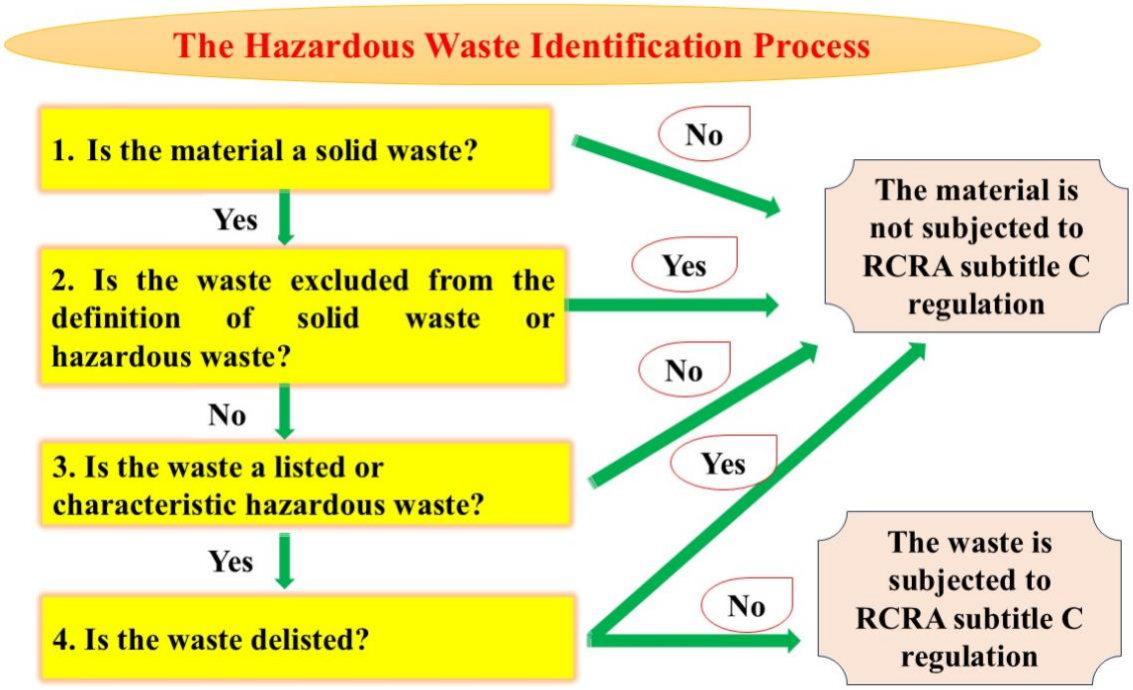
Step 4: Does the waste exhibit hazardous characteristics?

- If the waste is not listed, test whether it exhibits one or more hazardous characteristics: Ignitability, Corrosivity, Reactivity, and Toxicity

Step 5: Document and classify the waste

- Record the determination process in writing, including laboratory test results if applicable.

- Label the waste with the appropriate hazard classification.
- Maintain records for inspections, compliance audits, and future reference.



Identification of hazardous waste

11. Tools for Hazardous Waste Determination

- Provide hazard information for chemicals.
- Tests if waste leaches toxic substances.
- Official published lists of F, K, P, and U wastes.
- Past experience, process knowledge, and supplier documentation.

Storage

- All chemical wastes shall be stored using proper chemical segregation practices to avoid intermixing of incompatible materials.
- All chemicals shall be stored in a satellite accumulation area near where the waste was generated. Moving/relocating hazardous wastes away from where they were generated is prohibited.

- Additionally, no more than 55 gallons of hazardous waste (cumulative total of all wastes in an area) and only one quart of an acutely hazardous waste can be present within a single point of generation (laboratory or maintenance shop).

Labeling

- All hazardous waste containers shall be properly labeled with the words "Hazardous Waste", a description of the waste contained in the container, the hazards associated with the waste, and the location where the material was generated.
- If bottles are reused, remove the old chemical name and hazards completely and indicate the type of chemical waste on the container without abbreviations.
- Hazardous waste containers not labeled in accordance with this policy shall not be removed from the area until such label is affixed to the container the contents of the container are unknown, please indicate this on the label and in the waste pick-up request.

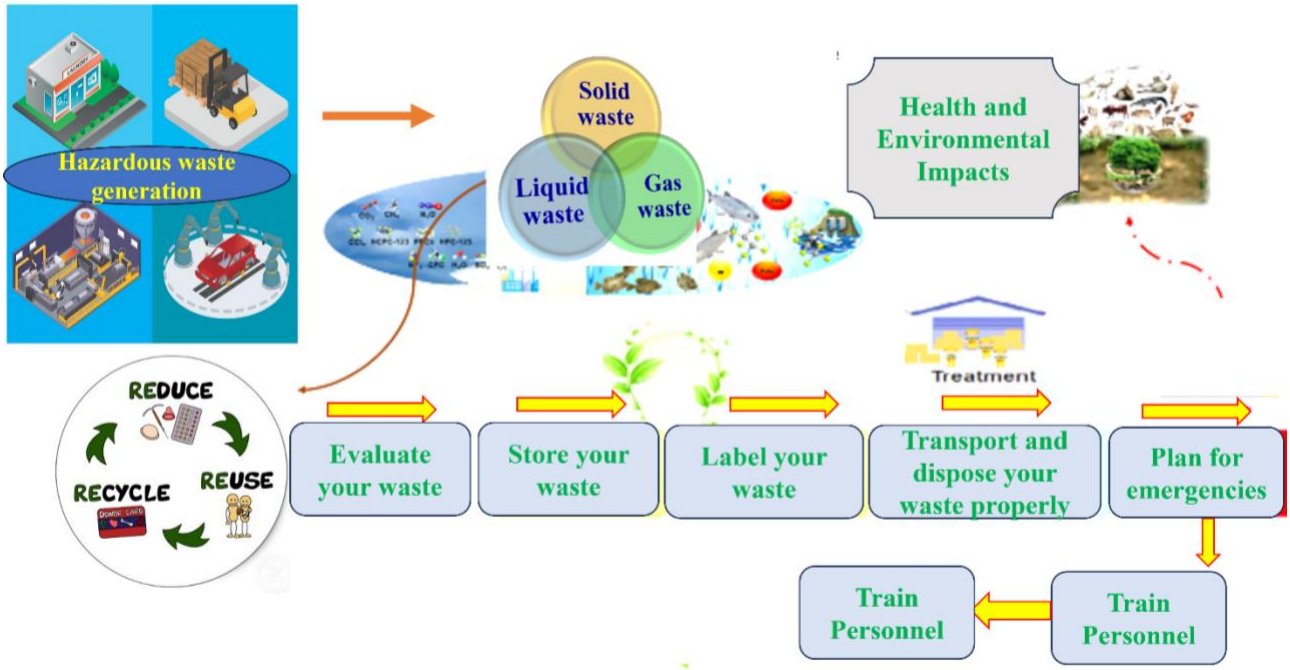
Packaging

- All hazardous waste shall be packaged in accordance with the following instructions:
- Use a leak-proof container that will safely contain the contents. Open chemical containers, plastic bags or culture dishes will not be accepted.
- Containers must be closable.
- The container shall not be overfilled with liquid waste.
- Empty space of at least five percent of the container volume shall be left to allow for thermal expansion.
- Be suspicious of any pressure build-up inside the container (e.g. piranha waste)
- If this is a concern when closing the container, use a cap designed to allow venting of over-pressure or do not secure the cap tightly and if appropriate, place the container inside a fume hood or other well-ventilated area until the chemical reaction has reached equilibrium and is removed by the waste collector.
- Old cans of dry picric acid or other shock-sensitive compounds and all known or suspected peroxide forming chemicals (PFC) shall be left in place and not moved until the waste collector

has evaluated the condition of the container. (Note: Friction, heat, and exposure to air can cause aging PFCs to explode).

- PFCs that MUST be disposed of within three (3) months of opening:
  - Divinyl acetylene
  - Divinyl ether
  - Isopropyl ether
  - Potassium amide
  - Potassium metal
  - Sodium amide
  - Vinylidene chloride
- PFCs that must be monitored for peroxides or discarded 12 months after opening. (This list is not exhaustive. Please check the dispose of the material per the manufacturer's expiration date.)
  - Acetal (1,1-diethoxyethane)
  - Acetaldehyde
  - Benzyl alcohol
  - 2-Butanol
  - Cumene
  - Cyclohexanol
  - 2-Cyclohexen-1-ol
  - Cyclohexene
  - Decahydronaphthalene
  - Diacetylene
  - Dicyclopentadiene
  - Diethyl ether
  - 4-Heptanol
  - 2-Hexanol
  - Methylacetylene
  - 3-Methyl-1-butanol

- Methylcyclopentane
- Methyl isobutyl ketone
- 4-Methyl-2-pentanol
- 2-Pentanol
- 4-Penten-1-ol
- 1-Phenylethanol
- 2-Phenylethanol



Handling the waste management step wise.

Empty Chemical Containers

- ❖ Chemical containers that have been emptied of their contents by normal methods are not regulated as hazardous waste.
- ❖ The container shall be triple rinsed with water or other suitable solvent and air-dried to ensure that it is free of liquid or other visible chemical residues before disposal.
- ❖ For volatile organic solvents (e.g., acetone, ethanol, ethyl acetate, ethyl ether, hexane, methanol, methylene chloride, petroleum ether, toluene, xylene), the emptied container can be air-dried in a ventilated area (e.g., a chemical fume hood) without triple rinsing.

- If the chemical is on the EPA Acutely Hazardous Waste "P" List, or if the material is known to be acutely toxicity, the washings/rinsate shall be collected and disposed of as hazardous waste by contacting Environmental Health and Safety and requesting a chemical pick-up.
- In most circumstances, it is advisable to dispose of the empty containers themselves as waste rather than create additional waste by triple rinsing them and collecting the washings.
- In addition to containers formerly containing acutely toxic materials, containers with residual reactive materials (pyrophoric, water-reactive, or strong oxidizers) should not be treated as empty and should instead be disposed of as hazardous waste.

Reuse of Reagent Bottles

- It is permissible to reuse empty reagent bottles for the collection of laboratory chemical wastes. However, before using a container it is important to verify that the container is free of incompatible residues and that the container itself is compatible chemical waste it will be used to store.
- Remove or deface all original markings and labels and label the container with the appropriate hazardous waste label.
- It is improper to dispose of volatile liquids by evaporating them.
- Only containers with residual amounts (<3%) of solvents that have been emptied of their contents through standard practices may be air-dried. Containers with more than residual amounts should be disposed of as hazardous waste.

Glass Containers

- Empty, intact, unbroken glass chemical containers that meet the above requirements for empty containers may be disposed of as regular laboratory waste in the general waste stream.
- Completely remove or deface chemical labels using a permanent black marker before disposal. Remove any caps from the bottles.
- Broken laboratory glassware free from any biohazardous, radioactive, and chemical contamination shall be disposed of by packing in a designated broken glass receptacle, cardboard box, or other rigid container. This includes the disposal of the following uncontaminated items: Broken glass and Glass vials.

- To minimize various potential hazards when discarding broken or un-serviceable glassware, the guidelines below shall be followed:
- Dispose of broken laboratory glassware in designated broken glass containers only. These shall be puncture-proof, double-lined cardboard boxes or other containers specifically designed for the disposal of glassware not weighing more than 20 pounds when full. These containers may be obtained from various laboratory equipment distributors;
- When the box is full, securely seal with tape to prevent any leaks;
- Label the container as "TRASH";
- Never use broken glassware boxes for the disposal of sharps, medical/biohazardous materials or liquid wastes;

Metal Containers

- Metal containers must be triple rinsed with water or other suitable solvent and air-dried. If the container is free of hazardous chemical residues, remove or deface any hazard markings or labels, it may then be placed in the regular laboratory trash or recycling receptacles.

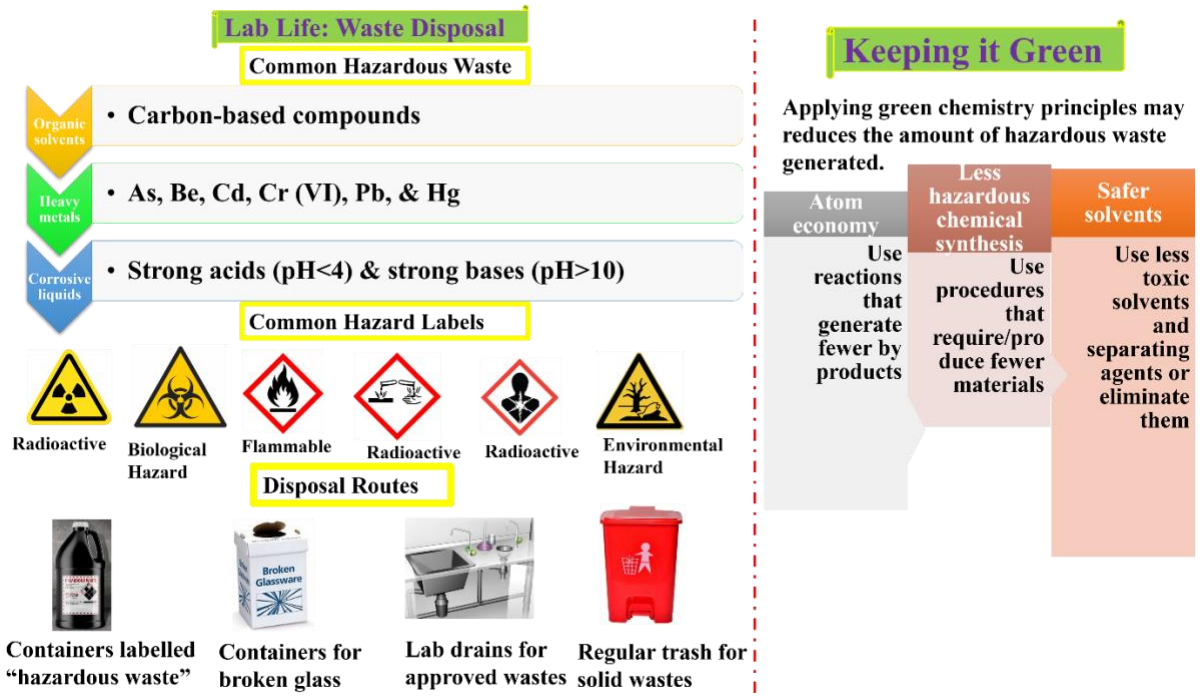
Secondary Containers

- Containers that were used as overpack for the primary chemical container may be placed in regular trash or recyclable trash.
- Any packing materials, such as vermiculite, perlite, clay, Styrofoam, etc., may be placed in the regular trash unless it was contaminated with the chemical as a result of container breakage or leak.
- Packing materials contaminated with hazardous materials shall be disposed of as hazardous waste.

Hazardous waste Minimization

- Only purchase what is needed for a three to six-month period;
- If practical, use non-hazardous materials;
- Segregate non-hazardous waste materials from hazardous wastes;
- Use sound chemical hygiene practices to avoid spills while handling chemicals and keep all containers closed when not actively adding/removing chemicals;

- If the chemical is still useful, recycle the waste instead of disposing of it by finding an associate that could use the remainder of the chemical;
- If the material can be safely neutralized at the point of use, then do so; and
- Properly label waste to communicate hazards, which helps the disposal vendor more accurately define/manage waste streams.



Waste disposal infographic

12. Container Management

- All hazardous waste satellite accumulation areas are required to follow proper container management practices while accumulating hazardous wastes.
- Use containers compatible with the waste collected. Place only compatible wastes in the same container.
- All containers holding hazardous waste must be labeled exactly as "Hazardous Waste" .
- Label all containers with the associated hazard of the waste i.e. ignitable, corrosive, reactive, toxic.
- Label all containers with the detailed contents of the container.
- Containers must be kept tightly closed when not being actively used.

- ❖ Keep containers of incompatible wastes physically separate. Use secondary containment as a best management practice.
- ❖ Use appropriate personal protective equipment (PPE) when handling waste . Contaminated PPE should be treated as hazardous waste.

13. Waste Management Hierarchy triangle in Chemistry Department of KKU

Waste Identification and Categorization

The first step in the waste management process in the Department of Chemistry at KKU is identifying the type of waste generated in the laboratories. Waste is categorized as either non-hazardous or hazardous. Non-hazardous waste is managed through normal disposal channels, while hazardous waste requires a structured and monitored procedure to ensure safe handling and environmental protection.

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Raising Requests for Hazardous Waste

Once hazardous waste is identified, the process begins with raising a request to the Head of the Chemistry Department. This step ensures proper documentation, oversight, and authorization for managing the waste. The involvement of the department head guarantees accountability and aligns with safety regulations.

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Coordination with Waste Management Company

After departmental approval, the next stage is informing the hazardous waste management company within KKU. This collaboration ensures that professionals trained in hazardous material handling are responsible for further processing. It also confirms compliance with institutional and environmental safety guidelines.

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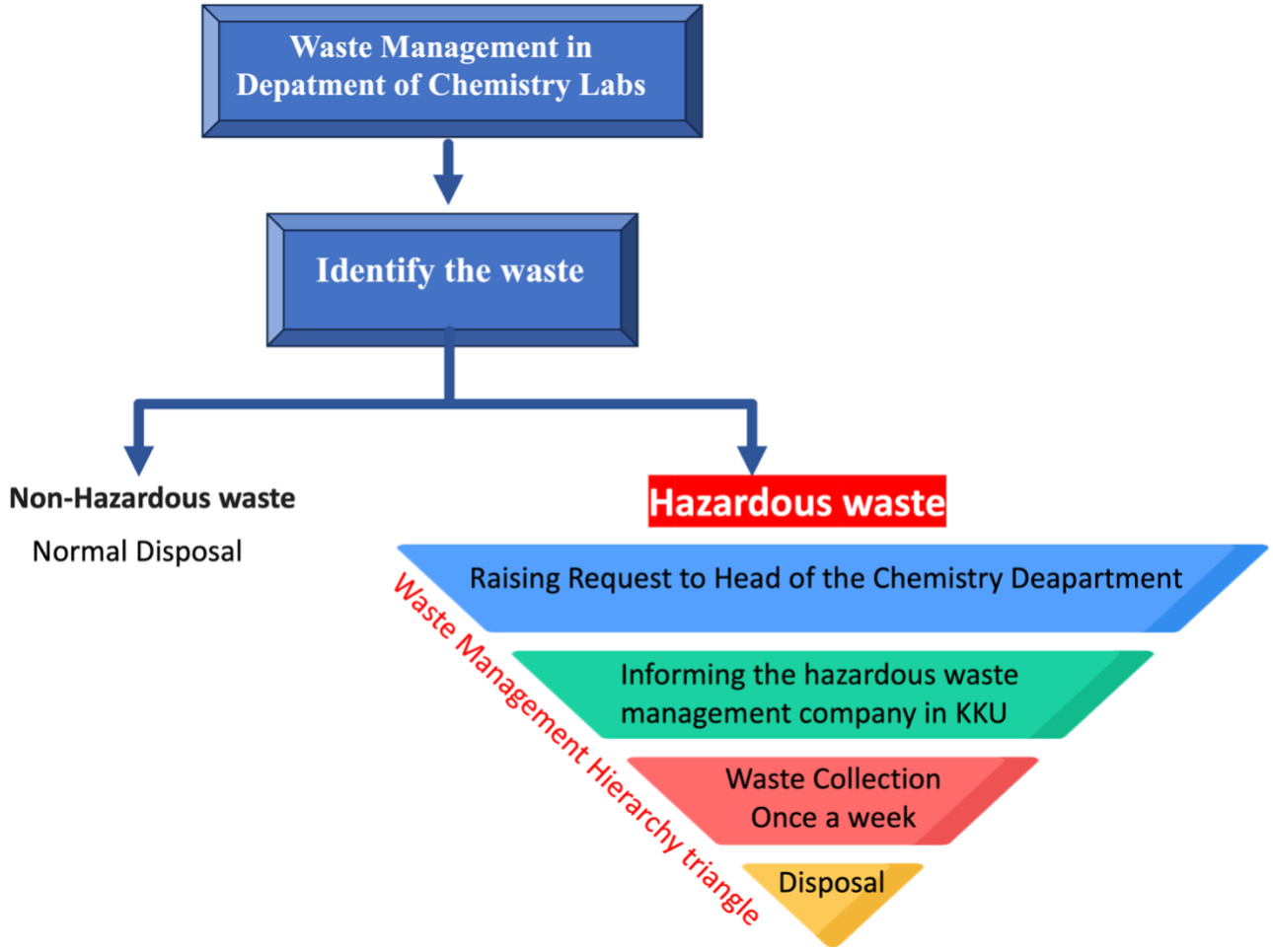
Scheduled Waste Collection

The hazardous waste management company then oversees waste collection on a weekly basis. This regular schedule prevents waste accumulation in laboratories, minimizes risks of contamination, and ensures a clean and safe working environment. By adhering to a fixed routine, the system reduces the chance of improper handling or storage of hazardous substances.

Final Disposal

The final step in the hierarchy is disposal. The hazardous waste collected is treated, neutralized, or disposed of according to established environmental and safety standards. This ensures that harmful substances do not pose risks to people, laboratory infrastructure, or the surrounding ecosystem**.**



14. Environmental Conservation Standards

- Every research and educational facility must implement practices that minimize environmental pollution and promote sustainable resource usage while ensuring that academic objectives are achieved responsibly.

- ❖ Water conservation should be addressed by installing efficient fixtures, recycling laboratory rinse water where possible, and promoting awareness among staff and students about avoiding unnecessary wastage.
- ❖ Energy efficiency is maintained through regular inspection of electrical systems, the use of LED lighting, smart sensors, and turning off laboratory and classroom equipment when not in use.
- ❖ Air quality is preserved by using proper fume hoods, regular ventilation system maintenance, and ensuring no hazardous fumes are released into the surrounding environment.
- ❖ Institutions should develop green campus initiatives, such as planting trees, creating pollution-free zones, and encouraging bicycle use or shuttle systems instead of private vehicle dependency.
- ❖ Procurement of laboratory materials should favor environmentally friendly products, including biodegradable cleaning solutions, low-toxicity reagents, and recycled paper for documentation.
- ❖ Waste segregation is essential, with color-coded bins for recyclables, biological waste, hazardous chemicals, and general trash to avoid cross-contamination.
- ❖ Environmental monitoring should be part of routine practice, where air, water, and soil quality checks are conducted periodically to ensure compliance with local and international conservation standards.
- ❖ Training programs should be designed to educate staff, faculty, and students on their roles in conserving energy, reducing waste, and promoting sustainable research practices.
- ❖ A periodic environmental audit should be carried out by an external agency or designated committee to assess the effectiveness of conservation measures and identify areas for improvement.

Hazardous Waste Disposal Standards

- ❖ Hazardous waste disposal must strictly follow national regulations such as EPA guidelines or equivalent regional standards to ensure safety and prevent environmental contamination.
- ❖ Each type of waste—chemical, biological, radiological, or electronic—should be separated at the source before being collected for final treatment or disposal.
- ❖ Proper labeling of hazardous waste containers is mandatory, including the chemical name, hazard category, date of generation, and responsible department.

- Storage areas for hazardous waste must be well-ventilated, secured from unauthorized access, and designed with spill containment measures such as secondary trays or absorbent barriers.
- Liquid chemical waste should not be poured into sinks or drains unless specifically approved by environmental health and safety authorities for neutralization and treatment.
- Solid hazardous waste must be collected in dedicated, resistant containers and transported only by certified hazardous waste contractors for incineration, landfilling, or other approved treatment methods.
- Biological waste must undergo decontamination (e.g., autoclaving or chemical disinfection) before being disposed of as medical or regulated waste.
- Radioactive waste requires specialized handling and must be stored in shielded, labeled containers until removed by licensed radiation waste management agencies.
- Records of hazardous waste generation, handling, transport, and disposal must be maintained for inspection and compliance verification.
- Institutions should establish emergency procedures for hazardous waste incidents, including spill control, evacuation plans, and immediate notification of safety officers.

15. List of Common Incompatible Waste

Below is a list of common chemicals and their respective incompatible chemicals.

CHEMICAL	INCOMPATIBLE CHEMICAL(S)

Acetic acid	aldehyde, bases, carbonates, hydroxides, metals, oxidizers, peroxides, phosphates, xylene
Acetylene	halogens (chlorine, fluorine, etc.), mercury, potassium, oxidizers, silver
Acetone	acids, amines, oxidizers, plastics
Alkali and alkaline metals	acids, chromium, ethylene, halogens, hydrogen, mercury, earth nitrogen, oxidizers, plastics, sodium chloride, sulfur
Ammonia	acids, aldehydes, amides, halogens, heavy metals, oxidizers, plastics, sulfur
Ammonium nitrate	acids, alkalis, chloride salts, combustible materials, metals, organic materials, phosphorous, reducing agents, urea
Aniline	acids, aluminum, dibenzoyl peroxide, oxidizers, plastics
Azides	acids, heavy metals, oxidizers
Bromine	acetaldehyde, alcohols, alkalis, amines, combustible materials, ethylene, fluorine, hydrogen, ketones (acetone, carbonyls, etc.), metals, sulfur
Calcium oxide	acids, ethanol, fluorine, organic materials
Carbon (activated)	alkali metals, calcium hypochlorite, halogens, oxidizers

Carbon tetrachloride	benzoyl peroxide, ethylene, fluorine, metals, oxygen, plastics, silanes
Chlorates	powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid	acetone, alcohols, alkalis, ammonia, bases
Chromium trioxide	benzene, combustible materials, hydrocarbons, metals, organic materials, phosphorous, plastics

Chlorine	alcohol's, ammonia, benzene, combustible materials, flammable compounds (hydrazine), hydrocarbons (acetylene, ethylene, etc.), hydrogen peroxide, iodine, metals, nitrogen, oxygen, sodium hydroxide
Chlorine dioxide	hydrogen, mercury, organic materials, phosphorous, potassium hydroxide, sulfur
Copper	calcium, hydrocarbons, oxidizers
Cyanides	acids, alkaloids, aluminum, iodine, oxidizers, strong bases
Hydroperoxide	reducing agents
Flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	alcohols, aldehydes, ammonia, combustible materials, halocarbons, halogens, hydrocarbons, ketones, metals, organic acids
Hydrocarbons (Such as butane, propane benzene, turpentine, etc.)	acids, bases, oxidizers, plastics

Hydrofluoric acid	metals, organic materials, plastics, silica (glass), (anhydrous) sodium
Hydrogen peroxide	acetylaldehyde, acetic acid, acetone, alcohol's carboxylic acid, combustible materials, metals, nitric acid, organic compounds, phosphorous, sulfuric acid, sodium, aniline
Hydrogen sulfide	acetylaldehyde, metals, oxidizers, sodium
Hypochlorites	acids, activated carbon
Iodine	acetylaldehyde, acetylene, ammonia, metals, sodium
Mercury	acetylene, aluminum, amines, ammonia, calcium, fulminic acid, lithium, oxidizers, sodium
Nitrates	acids, nitrites, metals, sulfur, sulfuric acid
Nitric acid	acetic acid, acetonitrile, alcohol's, amines, (concentrated) ammonia, aniline, bases, benzene, cumene, formic acid, ketones, metals, organic materials, plastics, sodium, toluene
Oxalic acid	oxidizers, silver, sodium chlorite
Oxygen	acetaldehyde, secondary alcohol's, alkalis and alkalines, ammonia, carbon monoxide, combustible materials, ethers, flammable materials, hydrocarbons, metals, phosphorous, polymers
Perchloric acid	acetic acid, alcohols, aniline, combustible materials, dehydrating agents, ethyl benzene, hydriotic acid, hydrochloric acid, iodides, ketones, organic material, oxidizers, pyridine

Peroxides	acids (organic or mineral)
Phosphorus (white)	oxygen (pure and in air), alkalis

Potassium	acetylene, acids, alcohols, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium chlorate	acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic materials, sugars
Potassium perchlorate (also see chlorates)	alcohols, combustible materials, fluorine, hydrazine, metals, organic matter, reducing agents, sulfuric acid
Potassium permanganate	benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Silver	acetylene, ammonia, oxidizers, ozonides, peroxyformic acid
Sodium	acids, hydrazine, metals, oxidizers, water
Sodium nitrate	acetic anhydride, acids, metals, organic matter, peroxyformic acid, reducing agents
Sodium peroxide	acetic acid, benzene, hydrogen sulfide metals, oxidizers, peroxyformic acid, phosphorous, reducers, sugars, water
Sulfides	acids
Sulfuric acid	potassium chlorates, potassium perchlorate, potassium permanganate

Revision of Safety Manual

The Chemistry Laboratory Safety Manual is a living document that requires regular updates to remain effective and relevant. To ensure that all policies reflect current best practices, technological advancements, and regulatory requirements, the manual will be reviewed once every six months. Additionally, revisions will be made whenever there is a necessity for a policy change, such as the introduction of new equipment, updated chemical handling procedures, or changes in institutional or governmental safety regulations.

All laboratory personnel will be informed of revisions, and the updated version of the manual will be distributed promptly. It is the responsibility of every laboratory user to familiarize themselves with the revised content and comply with updated policies.

16. Quick Run-Through of Laboratory Safety Rules/Policies

To reinforce safe laboratory practices, the following essential rules and policies must always be observed:

No Eating or Drinking

Food, drinks, and personal items must never be brought into or consumed in the laboratory.

Wear Personal Protective Equipment (PPE)

Safety goggles, lab coats, and closed-toe shoes are mandatory. Additional PPE such as gloves or face shields must be used when required.

Know Emergency Equipment

Be familiar with the locations of fire extinguishers, safety showers, eyewash stations, first aid kits, and emergency exits.

Handle Chemicals with Care

Always read chemical labels, never use unmarked containers, and handle all substances as potentially hazardous.

Label and Store Properly

Chemicals must be clearly labeled and stored according to compatibility and safety guidelines.

Dispose of Waste Correctly

Follow waste segregation protocols for chemical, biological, glass, and general waste. Never dispose of chemicals down the sink unless authorized.

No Unauthorized Experiments

Experiments must only be conducted under the supervision of the instructor or laboratory supervisor.

Report Accidents Immediately

All accidents, spills, or unsafe conditions must be reported without delay, no matter how minor they appear.

Maintain Clean Workspaces

Keep benches uncluttered, clean spills immediately, and return equipment to designated storage areas after use.

Stay Alert and Responsible

Avoid distractions, horseplay, or careless behavior. Safety is a shared responsibility and requires the full attention of every individual.

17. List of emergency contact numbers in Saudi Arabia

Inside King Khalid University

Direct Communication

Phone conversation for instant solutions.

Response Time: Within 5 days.

Service Availability: Throughout the week.

0172418000

Some Important Links for online Safety Data Sheets

Chemical Hazards and Toxic Substances

Hazardous Chemical Waste Management Guidelines

Hazardous Substances - Workplace Health and Safety

HAZARDOUS SUBSTANCE FACT SHEET