MIDDLE EAST TECHNICAL UNIVERSITY

DEPARTMENT OF CHEMICAL ENGINEERING

-SAFETY MANUAL-

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EMERGENCY PHONE LIST

METU Ambulance: 210 4142

METU Medical Center: 210 4960

METU Domestic Services: 210 2704 (off-hours: 210 2113)

All Emergencies*: 112

Fire: 110

Police Department: 155

For chemical waste, contact:

Yavuz Güngör and Erkan Kapusızoğlu: 210 2629

* Only by mobile phone

1 Introduction

This safety manual is intended as an introductory review of the policies and procedures to provide a safe environment in the METU Chemical Engineering Laboratories. The potential risks and hazards commonly encountered in the laboratory, measures to mitigate these risks, as well as information on Personal Protective Equipment (PPE) and waste handling and disposal are summarized.

Please note that this information is only meant as a preliminary guide and it is your responsibility to educate yourself on the specific risks and proper procedures regarding your own laboratory work.

Proper adherence to safety rules and policies at all times is vital to protect yourself and other people, such as co-workers and visitors, from laboratory hazards.

1.1 Potential Hazards

The potential hazards can be:

- Chemical
- Biological
- Radioactive
- Mechanical & Thermal
- Electrical
- Fire

1.1.1 Chemical Hazards

Chemical hazards are due to the toxic and corrosive substances, irritants and sensitizers etc.

- Corrosive and toxic materials induce destruction of living tissue by the way of chemical action with a contact. It is important to become familiar with the information related to the materials they may corrode, and their reactivity with other substances, also information on health effects. In most cases, these materials should be separated from other chemicals [1].
- Irritants are non-corrosive substances that induce reversible inflammatory impacts with a contact such as organic or inorganic compounds or many chemicals in the form of crystalline or powder. People should not contact with the irritants without safety glasses and gloves [1].

- When people exposed to sensitizers, they may develop an allergic reaction in normal tissue after a long time exposure to these substances such as diazomethane, chromium, nickel, formaldehyde, isocyanates, benzylic and allylic halides, and many phenol derivatives [1].

1.1.2 Biological Hazards

Biological hazards refer to organisms which pose a risk to the health of the human. The sources of biological hazards include parasites, bacteria, viruses, and proteins. Common biological hazards, control strategies and required personal protective equipment are shown in Table 1.

Table 1. *Common Biological Hazards, Control Strategies and Required Personal Protective Equipment [2]*

Common Biological Hazards	**Control Strategies**	**Required Personal Protective Equipment**
Exposure to blood borne diseases by way of needle stick, glass slides, tubes, pipettes or other sharps injuries	• Never use sharp and broken materials • Availability of sharp containers for disposal. • If necessary, get vaccinated	• Gloves, protective clothing, eye and face protection
Exposure to blood borne diseases by the way of contaminated items and surface	• If necessary, get vaccinated	• Gloves, protective clothing, eye and face protection
Exposure to environmental biological contaminants from ventilation systems, water or food	• Maintenance of ventilation systems.	• Gloves, protective clothing, eye and face protection and respiratory protection

1.1.3 Radioactive Hazard

The sources of this hazard are [3];

- Low frequency, radio frequency radiation, micro waves
- Infrared, visible and ultraviolet light
- X and gamma rays
- Alpha, beta rays, electron or ion beams, neutrons

- Laser

1.1.4 Mechanical and Thermal Hazard

Mechanical hazards are due to the moving material or equipment such as belts, drives and other rotating parts of the laboratory machines.

- **Control strategy:** Guard themselves against equipment and separate people from mobile equipment with barriers.

Thermal hazards are burns or other injuries due to the contact of people's with objects or materials which have a high or low temperature. Moreover, it is damage to health of people due to hot or cold working surrounding.

1.1.5 Electrical Hazard

The sources of electrical hazards are the electrical wiring or equipment. In order to prevent themselves from electrical hazard [3],

- Do not contact with live parts of electrical cords or worn cords.
- Do not approach to live parts under high voltage.
- **Control Strategy:** Check all electrical cords whether they are worn or not. Contact technician to repair damaged cords.

1.1.6 Fire Hazard

The sources of fire hazard are escalation of fire, lack of fire prevention or flammable and combustible materials.

Control Strategies [4]:

- Work with fire resistant materials, reduce the usage of combustible materials.
- Store the flammables in separate areas in their private metal containers.
- Put the extinguishers at required locations.

1.2 Responsibilities

Responsibilities of the student:

- Attending the Laboratory Safety Training and reviewing the Laboratory Safety Manual.
- Reviewing and signing the Graduate Student Orientation Checklist which can be seen in Appendix A.

- Reviewing the waste disposal requirements. Hazardous waste should be collected in 5 L HDPE (if compatible) waste containers (if not contact your supervisor). Hazardous Waste Disposal Form should be attached to each container showing the name (NO abbreviations or chemical formulas) and amount of each chemical. Hazardous waste is collected only on TUESDAYS by Yavuz Güngör or Erkan Kapusızoğlu.
- Following safety rules and procedures carefully.
- Cooperating with your supervisor in safety issues.
- Alerting your co-workers and supervisors on safety problems/violations.

Responsibilities of the supervisor:

The supervisor is in charge of the laboratory and should monitor all operations in his or her laboratory to provide a safe working environment to all personnel and visitors. In particular, the supervisor should:

- Assign a Laboratory Contact Person (see Appendix B).
- Ensure that all students and other laboratory personnel have completed the mandatory safety training *before* they attempt any laboratory work.
- Review and co-sign the Graduate Student Orientation Checklist with the student.
- Enforce the correct implementation of safety and waste management rules and procedures by all personnel and visitors.
- Advise and guide the laboratory personnel on the potential hazards and safety procedures specific to the particular research carried out in the laboratory.
- Ensure that the laboratory contains the MSDS and Safety Folders as well as all other documentation necessary to inform the personnel on the potential hazards.
- Ensure that all safety equipment, PPEs and other engineering measures (such as proper ventilation) are available and in working order.
- Audit, maintain and improve the laboratory environment as necessary to minimize the hazards in the workplace.

Responsibilities of the laboratory contact person:

The Contact Person is a senior researcher (post-doctoral researcher or experienced graduate student) who is authorized by, and assists, the supervisor in providing a safe working environment to the personnel and visitors. Specifically the Contact Person should:

- Act as a first point-of-contact when responding to emergencies or routine queries.

- Monitor the availability, accessibility and condition of the safety equipment, and report any problems with such equipment to the supervisor. In particular checking that
    - the first aid kit is complete and not past the expiration period (once a month),
    - the eyewash kits (boxes with dispenser bottles) are complete and not past the expiration period (once a month),
    - clean water flows from the safety showers and eyewash fountains (once a month),
    - the fire extinguishers are within the allowed (typically given) pressure range (once every three months).
- Maintain the MSDS and other safety documentation, and ensure they are complete and accessible to the laboratory personnel.
- Supervise the waste disposal and collection, and maintain copies of the hazardous waste disposal form for the laboratory records.
- Report any instances of unsafe behavior and situations to the supervisor.

Your <u>main</u> duty is to take care of your health and safety, and that of others.

1.3 Basic Safety Principles

There are a few, very basic rules that you should follow for all laboratory work:

- Become familiar with the hazards of the particular chemicals, experimental procedures and apparatus used, and educate yourself on how to protect yourself against these hazards.
- Be aware of the usage and location of safety equipment and facilities such as exits, first aid kits, fire extinguishers, safety showers and eyewash fountains.
- Be smart, stay alert and think before you act.
- Never work alone in the laboratory.
- Do not distract others.
- Never eat, drink, smoke or apply makeup in the laboratory.
- Use appropriate clothing that conforms to safety rules.
- Always use appropriate personal protective equipment such as chemically resistant laboratory coats, gloves and safety glasses.

- Learn to identify and understand safety labels and tags.
- Do not dispose of chemicals in any form in sinks or drains. Use appropriate waste bottles and apply the proper disposal procedures.
- Keep chemicals and apparatus well away from the edges of your laboratory bench or other workspace.
- Never remove chemicals from the laboratory without permission.
- Always wash your hands and arms with soap and water before leaving the laboratory.
- Report violations of your laboratory's safety rules to your instructors- you could save lives!

1.4 Entry Routes of Chemicals to the Body

Toxic materials can enter the body by four ways:

Inhalation: through the lungs by breathing contaminated air or gaseous discharge.

Ingestion: via the digestive tract by eating or drinking contaminated foodstuffs or swallowing chemicals.

Absorption: through body orifices such as ears, or existing cuts and wounds.

Injection: through needles or other sharp objects.

To prevent entry by inhalation of chemical vapors:

- Always use a fume hood when working with volatile chemicals.
- Never apply mouth suction to fill pipettes.
- Never smell chemicals.

To prevent entry by ingestion:

- Do not eat and drink, smoke or chew anything in the laboratory.
- Wear gloves when working with chemicals and wash your hands thoroughly before leaving the laboratory.

To prevent entry by absorption through skin or eyes:

- Never allow chemicals to touch your bare skin and hands.
- To protect your eyes and skin, always wear goggles, gloves and a laboratory coat.
- Discard your gloves immediately if you think they have been contaminated.

To prevent entry by injection:

- Use the sharps and syringes carefully. Dispose of needles, broken glass and similar sharp material in secure containers.

2 What are Material Safety Data Sheets?

MSDS is a reference intended to train workers on the hazards and precautions for the chemicals that they will use. The MSDS for a hazardous chemical describes its hazards and precautions you must take to avoid harm.

A hazardous chemical can be defined as any chemical that presents a hazard either under normal use or in a foreseeable emergency.

- MSDS sheet must be present for each hazardous chemical used in the work area.
- MSDS must be accessible to all people whenever they are in the work area.
- If you need MSDS of a chemical, visit **http://www.hazard.com/msds/index.php**

A Typical MSDS Provides Information About

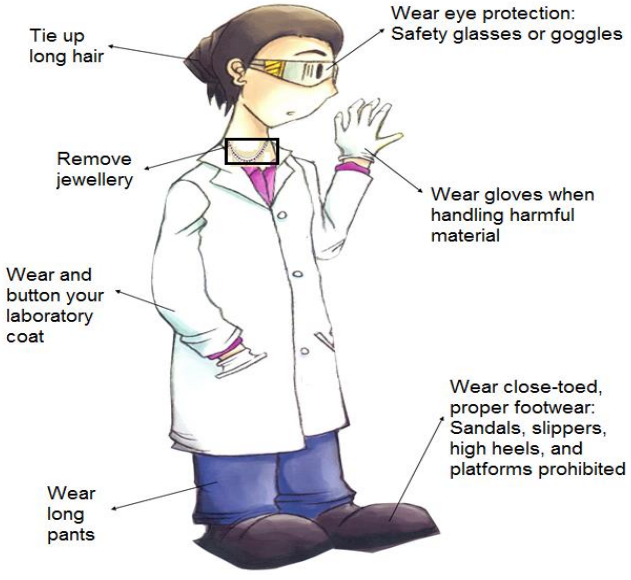
- Identification of chemicals
- Composition and information on ingredients
- Hazard identification
- First-aid measures
- Fire and explosion data
- Spill and leak procedures
- Handling and storage
- Personal protective equipment
- Physical data
- Reactivity
- Toxicological considerations
- Disposal considerations
- Transport information
- Regulatory information

3 Laboratory Attire and Personal Protective Equipment

Proper clothing and personal attire are key components of your safety. In particular, the use of appropriate Personal Protective Equipment (PPE) is mandatory at all times. PPEs are eye, foot and body-wear designed to resist hazardous environments. The most common PPEs are laboratory coats, safety glasses (or goggles) and gloves. You should be aware that certain environments require additional specialized gear, for example cryogenic gloves for handling low-temperature apparatus, helmets to guard you against physical impact and face masks or shields for certain chemicals and applications. The proper Personal Protective Equipment is shown in Figure 1.

The following are a summary of guidelines for the personal attire you wear in the laboratory:

- Always wear **LABORATORY COATS** and button them up in the laboratory.
- Always wear **LONG PANTS** that covers your legs to provide more protection.
- Always wear **CLOSED-TOED SHOES.** Slippers, sandals, woven shoes, high heels, platforms, and similar footwear might compromise your safety and are also prohibited.
- Always wear **GLOVES.**
- Always wear **SAFETY GLASSES or GOGGLES.**
- Always tie up long hair.
- Remove jewelry such as chains and bracelets.



http://www.ntu.edu.sg/ohs/safetyforeveryone/Pages/SafetyPoster.aspx

Figure 1. *Personal Protective Equipment (PPE)*

3.1 Personal Protective Equipment: Eyewear - Goggles and Safety Glasses

Everyone in the laboratory, including visitors, must wear splash-proof goggles or safety glasses at all times, even when not performing a chemical operation.

Goggles or safety glasses must be worn at all times in the laboratory!

Ordinary prescription eyeglasses you might have do not qualify as eye protection. Never rely on such glasses in the laboratory. Contact lenses similarly cannot provide adequate protection in any environment. Always wear goggles or safety glasses.

Goggles seal completely around the eyes and provide splash protection from top, bottom, and the sides, as well as from the front. Safety glasses resist splashes from the front and the sides. The most used safety glasses are shown in Figure 2.

Figure 2. *Commonly used safety eyewear: Goggles (left), Safety Glasses (right)*

3.2 Personal Protective Equipment: Gloves

Gloves are an important part of personal protection. Different types of gloves are available but the important issue is which glove type should be worn in the laboratory.

- To select the appropriate glove type for your work, check:
  - The chemical composition of the substance you are working with.
  - The properties of the glove material and in particular its *breakthrough-time* for the chemicals used.
  - Whether you are allergic to the glove material.
- Always confirm that the gloves are intact. Discard gloves with cuts and ruptures.
- Do not touch your face, telephone, notebooks etc. with contaminated gloves.
- Do not wear gloves outside the laboratory.
- Do not reuse gloves if they previously have been permeated by a harmful chemical.

3.3 Personal Protective Equipment: Clothing

Clothing should protect people from splashes and spills in the laboratory. A laboratory coat and long pants should be worn. Additional body wear such as aprons should be worn whenever demanded by the safety guidelines of a specific application.

- Do not wear open toed shoes, sandals, high-heeled shoes.
- Do not wear shorts, cutoffs and short skirts.
- Do not wear jewelry such as rings, bracelets and wristwatches. Wearing jewelry increases the possibility of accident due to the electrical source.

4 Safety Signs and Symbols

Safety symbols and signs help you by saying how you have to behave in a laboratory for a safe operation. Some examples of these signs are given in Figure 3. The list is far from exhaustive and you should learn to find and recognize specific signs in your area.

Figure 3. *Some examples of Safety Symbols and Signs*

5 Labeling of Chemicals

5.1 The NFPA Diamond

- Among several standards to label chemicals, one very common labelling standard is NFPA diamond (National Fire Protection Agency of the United States).
- NFPA diamond contains four major categories: Health, Flammability, Reactivity and Specific.
- Hazards are rated from 0 (very low) to 4 (extreme) in each category. Each number in the corresponding color represents the level of the hazard.
- NFPA is usually abbreviated in the MSDS sheets and is placed on the chemical bottles by many manufacturers.

NFPA Diamond symbol is shown in Figure 4 and the meaning of each color and numbers are given in Table 2.

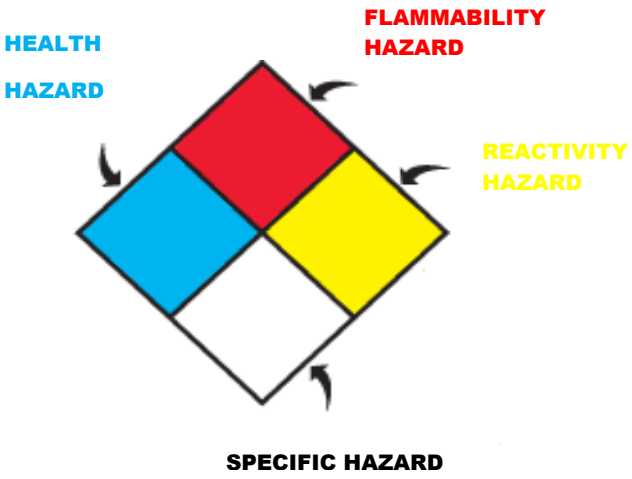


Figure 4. *NFPA Diamond Symbol*

Table 2. *The meanings of numbers and colors*

HEALTH HAZARD	**FLAMMABILITY HAZARD**
The classification of hazard on health is assigned as follows: **4-EXTREME**-Highly Toxic- May be fatal on short-term exposure. **3-SERIOUS**-Toxic-Full protective suit and breathing apparatus should be worn. **2-MODERATE**- Breathing apparatus and face mask should be worn. **1-SLIGHT**- Breathing apparatus should be worn. **0-MINIMAL**-No precautions necessary.	Susceptibility to burning is criteria for assigning degrees. **4-EXTREME**-Extremely flammable gas or liquid. Flash point below 22.8 ºC (73ºF). **3-SERIOUS**-Flammable. Flash point: 22.8 ºC (73ºF) to 37.8 ºC (100ºF). **2-MODERATE**-Combustible. Requires moderate heating to ignite. Flash point below 93.3 ºC (200ºF). **1-SLIGHT**-Slightly combustible. Requires strong heating to ignite. **0-MINIMAL**-Will not burn under normal conditions.
SPECIFIC HAZARD	**REACTIVITY HAZARD**
It indicates the classification of hazardous materials **OXIDIZING-(OX) -** Any substance that gives up oxygen easily **ACIDIC-(ACID)**- pH < 7 **ALKALINE-(ALK)-** Any base that dissolves in water **CORROSIVE–(COR)-** Any substance with pH ≤ 2.5 or pH ≥ 12.5 **WATER REACTIVE-(-W-)** -Any substance that may react with water **RADIOACTIVE-(☢)**- Any substance that produces radiation	Susceptibility of materials to release energy is criteria for assigning degrees. **4-EXTREME**-Explosive at room temperature. **3-SERIOUS**-May detonate if shocked or heated under confinement or mixed with water. **2-MODERATE**- Unstable. May react with water. **1-SLIGHT**- May react if heated or mixed with water. **0-MINIMAL**-Normally stable. Does not react with water.

Retrieved from http://www.enggcyclopedia.com/2012/02/nfpa-diamond-label/

For example, for sodium NFPA Diamond Symbol is shown in Figure 5.

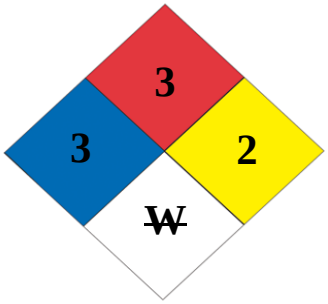


Figure 5. *NFPA Diamond Symbol for Na*

NFPA Diamond shows that Na is a flammable, toxic and unstable material. Moreover, it is a water reactive element. Another example of NFPA Diamond Symbol which is shown in Figure 6 is Bromine.

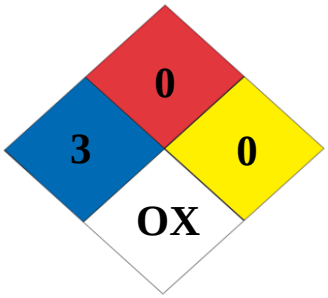


Figure 6. *NFPA Diamond Symbol for Br*

NFPA Diamond shows that Bromine will not burn under normal conditions and it is toxic and stable material. Moreover, it is an oxidizing agent.

5.2 Labeling: Chemical Hazard Symbols

Some of the chemical hazard symbols are shown in Figure 7. For full list, you can visit http://chemistry.about.com/od/healthsafety/ig/Laboratory-Safety-Signs/

- These symbols are internationally agreed.
- The door of storage room or chemical cabinets must be labelled with respect to its contents.
- The chemical containers must be labelled by these symbols with respect to its content.

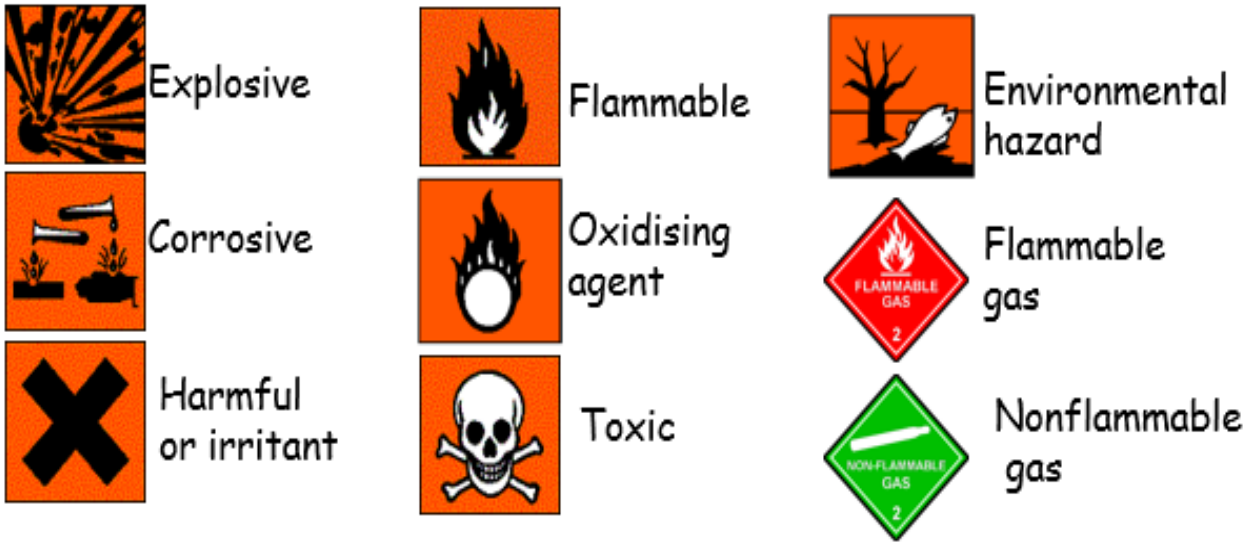


Figure 7. *Some General Chemical Hazard Symbols*

Biological and radiation hazard symbols are shown in Figure 8.

Figure 8. *Biological Hazard Symbol (left), Radiation Hazard Symbol (right)*

5.2.1 Safety Signs and Symbols: Education Chart

Education charts consist of specific warnings and danger symbols for students or personnel. The education chart used in our department is shown in Figure 9.

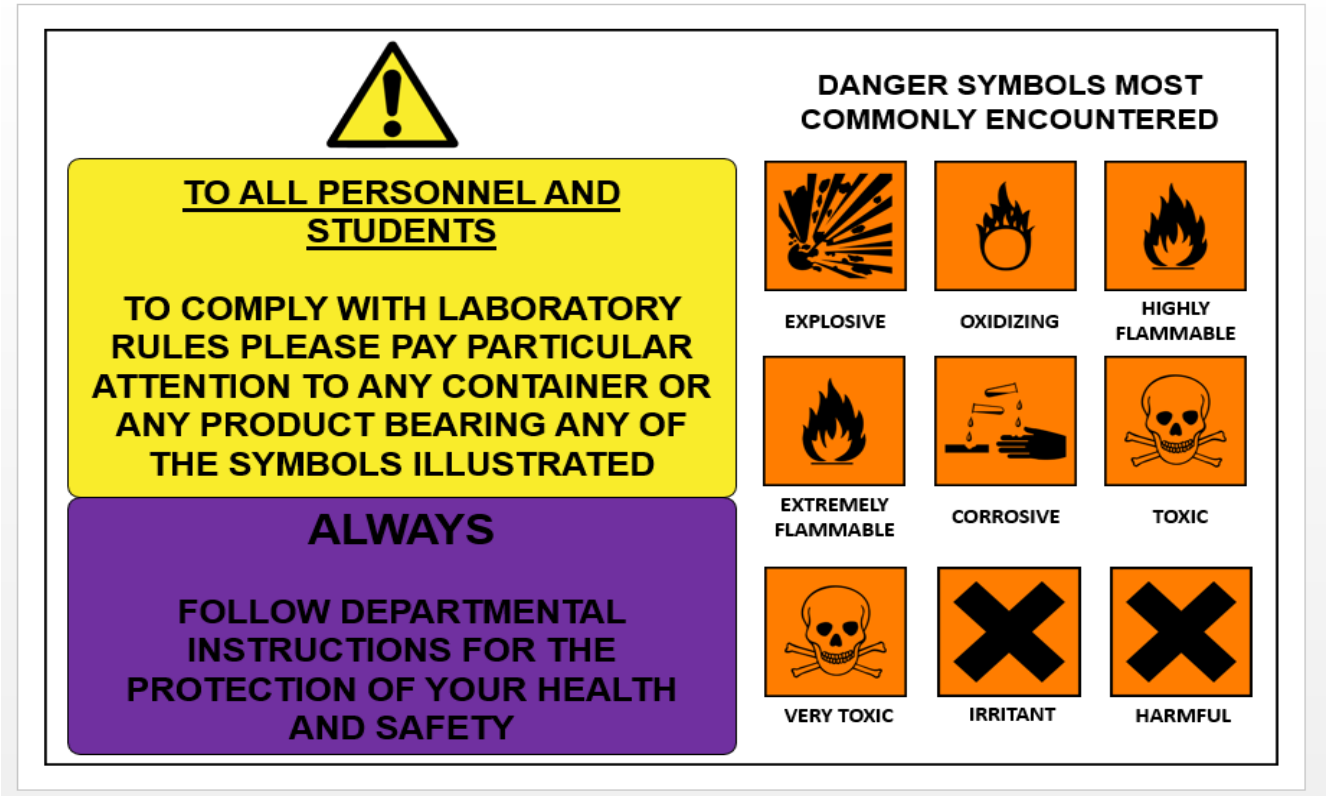


Figure 9. *Example Education Chart*

5.3 Labeling: Chemical Containers Generated in the Laboratory

- All containers must be labelled.
- The label should include (see figure 10):
  - The name of the chemical(s) with the concentration/composition of each ingredient. Avoid formulas, commercial names and abbreviations.
  - Concentration and purity
  - Date of preparation/packaging.
  - Information on potential hazards and precautions to take
  - Name of the person who uses/generated the material.
  - Expiration dates and shelf lives.

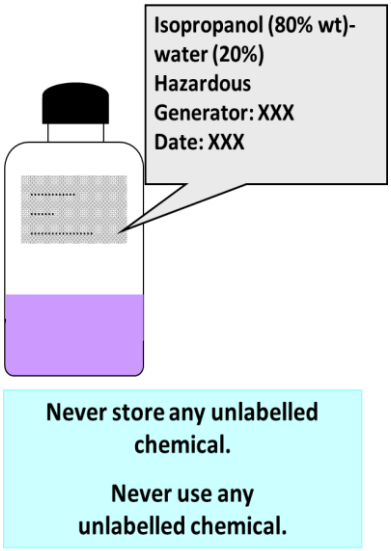


Figure 10. *The Example of Labelled Chemical Container*

6 Storage and Handling of Chemicals and Other Hazardous Materials

In laboratories, there are various types of chemicals used and stored. These chemicals can be classified according to their physical and chemical properties. The explanations of each chemical type are given in Appendix C.

Storage must be in:

- closed metal containers inside a storage cabinet
- safety cans, or an inside storage room
- an inside storage room

The examples of the metal container in E-Block Coal Laboratory of Chemical Engineering Department are shown in Figure 11.

Figure 11. *Metal Containers for Corrosive (left) and Flammable (right) materials*

- Laboratories have established separate storage areas for
  - Flammable and combustible organic liquids and solvents
  - Acids
  - Dry poisons, salts, and oxidizers
  - Bases
- Chemicals are stored in
  - Chemical storage cabinets
  - Flammable storage refrigerators (No food)
  - Chemical storage refrigerators/freezers (No food)
  - On shelves with retaining barriers
- Identify incompatible chemicals – check the Material Safety Data Sheet
- Isolate and separate incompatible materials
  - Isolate by storing in another area or room
  - Degree of isolation depends on quantities, chemical properties and packaging
  - Separate by storing in same area or room, but apart from each other

6.1 Basic Guidelines

Basic information that outlines storage and handling rules for hazardous material typically found in research laboratories is summarized in Table 3.

Table 3. *Hazardous substances and their usage/storage limitations [5], [6]*

Flammable Liquids/Gases	• Flammable liquids should be preferably stored in metal or glass containers. • Store in the air-conditioned cabinets. • Store limited amounts of flammable material in laboratories. • Store them separately from chemicals, acids or oxidizing agents. • Protect flammable material against ignition sources. • Keep flammable material away from flames, heat or direct sunlight. Locate portable heaters away from combustible materials. • Do not heat flammable liquids directly over a burner or on an electrical device that can generate sparks, or that has a surface temperature in excess of that which might cause auto-ignition.
Compressed Gas Cylinders [7]	• High-pressure gases, typically contained in cylinders, are a potential hazard due to their pressure, flammability and toxicity. Even inert gases at low pressure can pose a hazard by diluting breathable air to unsafe levels. • Keep cylinders away from flames, heat or direct sunlight. The ambient temperature should be below 40 ^{o}C at all times. • Most gases are colorless and odorless, so leaks are almost impossible to detect by sight or smell. Check regularly for leaks. • Inspect valves and regulators periodically for wear and damage. Use the correct regulator type and familiarize yourself thoroughly with the correct operation of the valve-regulator combination. Close valves when your setup is not in use. • Maintain cylinders in upright position and secure them to the wall using a chain. • Disconnect the pressure regulator, screw on the protective caps of the cylinders when the cylinders are empty, disconnected from the setup, in transport or storage. • Do not drag, roll or bump cylinders – use a cart with securing belts or chains for transport. • Never change the color of the cylinders, but do not assume contents based on color alone – the actual contents should be stenciled on the cylinder. • Separate and store according to their contents – e.g. store oxidizer gases away from flammables.

Table 3 *Continued*

	• Remove empty cylinders from the laboratory to minimize risk.
Corrosive Acids and Bases	• Store corrosive acids away from metals or cellulosic materials • Store strong organic acids separately from mineral acids • Store strong acids away from strong bases • Do not store acids near explosive gases, or hydrogen
Water-Reactive Materials	• Keep these materials dry at all times
Organic Peroxides	• Store at the lowest possible temperature consistent with solubility or freezing point
Liquid Nitrogen (extremely cold:-196^{o}C)	• Wear specific personal protective equipment such as cryogenic gloves and googles. • Store in the ventilated areas and in the upright position • Avoid breathing liquid nitrogen vapor • Use only containers specially designed to hold liquid nitrogen • Transfer from the primary container to bench top container which is used for small scale in the laboratories slowly to prevent thermal shock

For further information, do not forget to look at the MSDS's of chemicals.

6.2 Incompatible Chemicals

Contact between incompatible chemicals can result in poisonous or flammable gases, explosions, or spontaneous ignition. For this reason, incompatible chemicals should be stored separate from each other. A partial list of incompatible chemical combinations is given in Table 4. The chemicals listed in the right column should not be allowed to come into contact with the chemicals in the left column.

Table 4. *Incompatible Materials [1], [5]*

Acetone	Concentrated Acids, Nitric Acid, Perchloric Acid, Peroxides, and Permanganates
Alkali and Alkaline Earth Metals such as Sodium, Potassium, Lithium, Magnesium, Calcium, Aluminum	Carbon Dioxide, Carbon Tetrachloride and other Chlorinated Hydrocarbons (also do foam on fires involving the metals in the left column)
Acetylene	Chlorine, Bromine, Copper, Silver, Fluorine, and Mercury
Hydrogen Peroxide	Chromium, Iron, most metals or their salts, any flammable liquid, combustible materials, Aniline,
Nitric Acid	Acetic Acid, Aniline, Concentrated Caustics, Chromic Acid, Hydrocyanic Acid, Hydrogen Sulfide, Flammable liquids and gases, and Nitritable substances
Oxygen	Grease, Hydrogen, Flammable liquids, and gases and solids

For further information, do not forget to look at the MSDS's of chemicals.

7 Hoods and Exhaust Systems

Hoods and exhaust systems vent their contents to the atmosphere to remove hazardous, flammable and poisonous gases and radioactive materials away from storage areas and the laboratory. When working with volatile and hazardous acids, strong oxidizing agents or highly reactive chemicals, hood systems vent these chemicals to the atmosphere without releasing them into the laboratory workspace. The hoods are designed for usage when working with chemicals and should not be used for long-term storage of chemicals [5]. A list of safe practice rules and guidelines is given below:

- Always use a fume hood when working with volatile chemicals
- Do not work in a hood, if it is damaged, unoperational or has poor air flow.
- Do not block the flow of air into the hood.
- The face velocity of the hood should be between 0.4 and 0.5 m/s.

8 Waste Disposal

Properly handling waste chemicals and contaminated materials is a major part of accident prevention. Every student has the responsibility of handling waste chemicals in accordance with the designated rules and regulations, which minimizes the possibility of accidents. In the laboratories labelled different containers are used for different classes of chemicals. Types of chemical wastes and their contents are shown in the following Table 5.

Table 5. *Types of wastes and contents*

Types of wastes	**Content of the wastes**
Aqueous waste (<40% Organic Chemicals) • **Do not store in metal!**	• Acidic • Neutral • Basic
Organic Waste (>40% Organic Chemicals)	• Non-chlorinated (ethyl acetate, hexanes, methanol, toluene) • Chlorinated (chloroform, chlorobenzene)
Solid Waste	• Lightly Contaminated (gloves, empty or broken tubes) • Chemical (used filter paper, unwanted samples,
Special Cases	• Sharps

Retrieved from https://greenchemuoft.wordpress.com/2015/04/20/proper-chemical-waste-disposal-posters-memes/

For each chemical waste, separate containers must be used and labelled with the official Waste Form of the Chemical Engineering Department. The Waste Form should contain:

- The accumulation start date and the date of reception by the collection personnel.
- Generator of the waste and the Principle investigator
- Container contents, their amounts and units

- Category of danger
- Net quantity contained
- Generator signature

Hazardous and biological waste disposal form and the attachment wire are given by Mr. Yavuz Güngör or Mr. Erkan Kapusızoğlu. The iron wire is attached to the hole at the top of the form and the form is affixed to the waste container with this wire. The form consists of three pages. The first page, white, is filled by the owner of the waste container. This page is left on the container. The second page, blue, is taken by Yavuz Güngör or Erkan Kapusızoğlu and the final page, yellow, is archived by the supervisors.

The Hazardous Waste Disposal Form is shown in Figure 12.

TEHLİKELİ ATIK – HAZARDOUS WASTE
ODTÜ Kimya Mühendisliği Bölümü
METU Department of Chemical Engineering

Dolum başlangıç tarihi: (Accumulation Start Date) ____ /____ /_____	**Teslim edilen tarih:** (Received Date) ____ /____ /_____	
Oluşturan Kişi: (Generator)	**Sorumlu Öğretim Üyesi:** (Principle Investigator)	**Oda No:** (Room No)
Acil Durum Telefon: (Emergency Call Phone) 1) 2)		**Telefon:** (Phone)

Kabın İçeriği (Container Contents)	**CAS #**	**Miktar** (Amount)	**Birim** (Unit)

Devamı var (Continued on Next Tag): **Evet** (Yes) ☐ **Hayır** (No) ☐

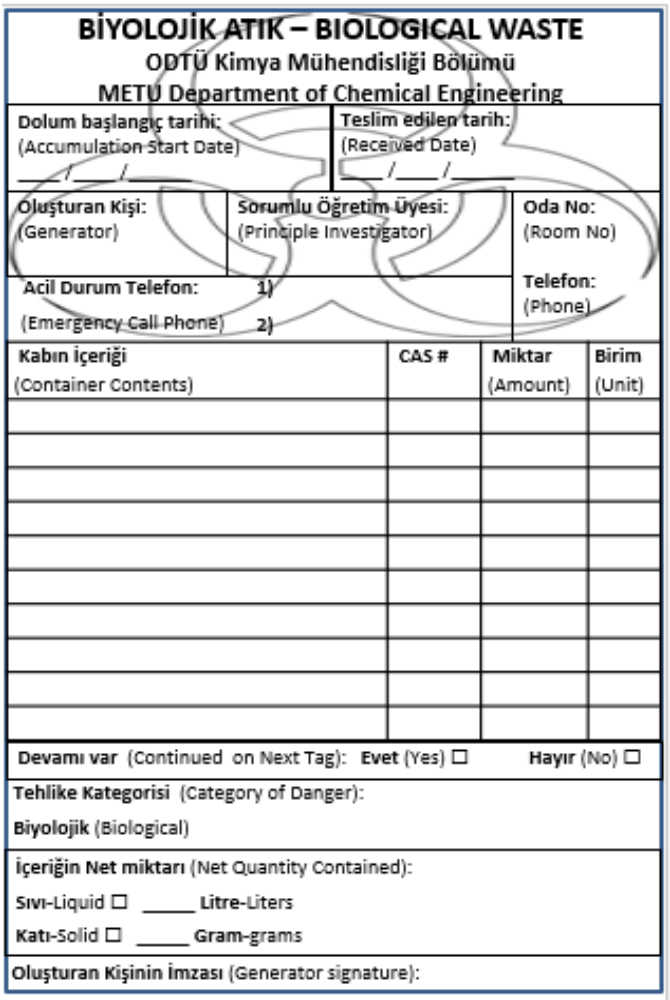
Tehlike Kategorisi (Category of Danger):
Patlayıcı (Explosive) ☐ **Oksitleyici** (Oxidizing Agent) ☐
Yanıcı (Flammable) ☐ **Aşındırıcı** (Corrosive) ☐
Zehirli (Toxic) ☐ **Zararlı/Tahriş edici** (Harmful/Irritant) ☐

İçeriğin Net miktarı (Net Quantity Contained):
Sıvı-Liquid ☐ _____ **Litre**-Liters
Katı-Solid ☐ _____ **Gram**-grams

Oluşturan Kişinin İmzası (Generator signature):

Figure 12. *Hazardous Waste Disposal Form*

The biological waste disposal form is separate and shown in Figure 13.



BİYOLOJİK ATIK – BIOLOGICAL WASTE

ODTÜ Kimya Mühendisliği Bölümü

METU Department of Chemical Engineering

Dolum başlangıç tarihi: (Accumulation Start Date) ___/___/___	**Teslim edilen tarih:** (Received Date) ___/___/___	
Oluşturan Kişi: (Generator)	**Sorumlu Öğretim Üyesi:** (Principle Investigator)	**Oda No:** (Room No)
Acil Durum Telefon: (Emergency Call Phone) 1) 2)		**Telefon:** (Phone)

Kabın İçeriği (Container Contents)	**CAS #**	**Miktar** (Amount)	**Birim** (Unit)

Devamı var (Continued on Next Tag): **Evet** (Yes) ☐ **Hayır** (No) ☐

Tehlike Kategorisi (Category of Danger):

Biyolojik (Biological)

İçeriğin Net miktarı (Net Quantity Contained):

Sıvı-Liquid ☐ _____ **Litre**-Liters

Katı-Solid ☐ _____ **Gram**-grams

Oluşturan Kişinin İmzası (Generator signature):

Figure 13. *Biological Waste Disposal Form*

The rules for proper waste disposal [8] are as follows;

- Wear personal protective equipment when handling waste.
- Accumulate the wastes at designated location.
- Select the container type which is compatible with the waste type. In our department, hazardous waste is collected in 5 L High Density Polyethylene (HDPE) waste containers.
- Check the MSDS of wastes, do not combine incompatible chemicals.
- Choose proper containment to match with the waste volume.
- Do not completely fill the bottles more than 80% of the bottle volume.
- Do not mix incompatible waste chemicals (Table 4).
- Keep halogenated and non-halogenated wastes separate.
- Never store flammables with oxidizers or acids.
- Every contained must be clearly labelled with waste form.

- Store the waste containers in the secondary containers.

Hazardous waste is collected only on TUESDAYS.

- Contact Yavuz Güngör or Erkan Kapusızoğlu before delivering the waste containers.

For gas cylinders,

Gas cylinders are labelled with the Gas Cylinder Status Tag as shown in Figure 14.

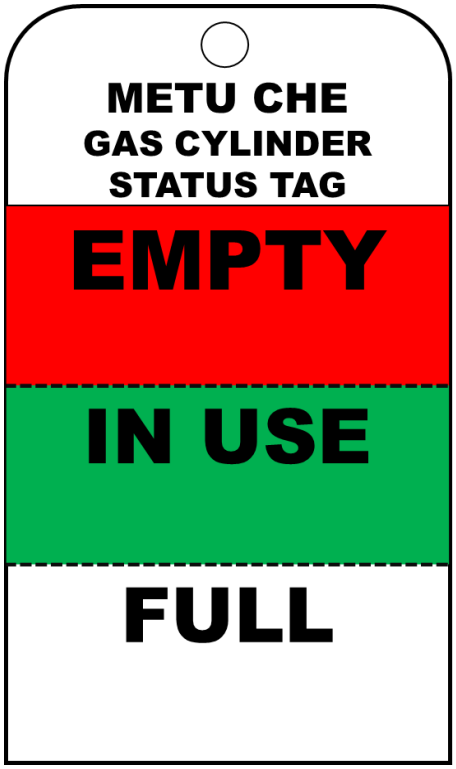


Figure 14. *Gas Cylinder Status Tag*

When the gas in the cylinder is in use, the “FULL” tab is torn off and when the gas cylinder is empty, the “IN USE” tab is torn off so that it is known that the gas cylinder is empty.

9 Fire Safety

Many solvents used in the laboratory are flammable.

- Avoid using flames whenever possible: Prefer hot plates for heating rather than Bunsen burners for example.
- Make sure that your fire extinguishers are in working order.

10 Electrical Safety

Do not become a part of an electrical circuit. Observe the following rules:

- Make sure that your equipment and laboratory have circuit-breakers that are in working order.
- Do not leave equipment that may overheat, unattended.
- Do not use extension cords.
- Do not use any equipment that contains electrical wire without insulation. Inspect and replace cords in which bare wires are exposed due to wear and tear of the insulating material.
- Keep electrical equipment dry and away from bare metal objects that may cause an electrical discharge.
- Make sure that plugs are unobstructed and in good condition.
- Never try to maintain or repair electrical equipment. Let qualified people do this work for you.

11 Mechanical Safety

- Make sure that belts, pulley drives and other rotating parts of the laboratory machinery are covered.
- When lifting a heavy object, use your legs. Do not bend over and pick it up with your back muscles.

12 First Aid: Important Rules

REPORT ALL INJURIES TO YOUR SUPERVISOR NO MATTER HOW UNIMPORTANT THE INJURY MAY SEEM.

IF YOU ARE INJURED, ASK FOR MEDICAL ATTENTION, HELP AND ADVICE.

IF SOMEONE ELSE HAS BEEN INJURED, DO NOT EXPOSE YOURSELF TO DANGER WHEN HELPING YOUR FRIEND.

DO NOT MOVE ANY INJURED PERSONS UNLESS THEY ARE IN FURTHER DANGER. KEEP THEM WARM. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON

Eyes: Flush with water for 15 minutes

Ingestion: Follow label and MSDS instructions

Skin Contact: Stand under emergency shower and remove contaminated clothing immediately

Inhalation: Get to fresh air and get prompt medical attention

13 Emergency Procedures

Emergencies can happen, so

- Avoid working alone in the laboratory.
- Know where emergency phone numbers are posted.
- Review MSDS.
- Know where to go and what to do in an emergency.
- Know the location of the closest safety showers, eyewashes, and fire extinguishers.

13.1 Emergency: Calling the METU Domestic Services or Medical Center

- Move to a safe location first and notify your superiors.
- Notify others in the area about the nature of the emergency.
- Call the METU Domestic Services or METU Medical Center and do not forget to report

  - your name, location and telephone number
  - the full address and a safe, accessible location where you can meet the emergency personnel
  - the nature of the emergency, whether an explosion has occurred or whether there has been a chemical or electrical fire
  - if individuals are involved, how many and, whether they are unconscious or trapped
- Meet the fire crew or ambulance at the place you indicated.

13.2 While Waiting for Assistance

- Do not move injured persons unless they are in further danger. Keep them warm. Unnecessary movement can severely complicate neck or spinal injuries and fractures.
- If chemicals have been spilled on a person, immediately remove all contaminated clothing and get the individual under a shower to wash the affected area thoroughly. If chemicals are in the eyes, irrigate with plenty of water for at least 15 minutes.
- Anyone overcome with smoke or fumes should be removed to uncontaminated air and treated for shock.

14 References

[1] *UCLA Laboratory Safety Manual*. (2011). Office of Environment and Safety.

[2] *Handbook of Occupational Hazards and Controls for Pharmacy Workers*. (pp. 0–57) (2011). Government of Alberta.

[3] M. Rausand. (2005). Hazard *Checklist* (pp. 1–10). Department of Production and Quality Engineering. Norwegian University of Science and Technology.

[4] *How to identify hazards requiring risk management?* (2006). The Victorian WorkCover Authority.

[5] *Study Materials for the Certificate of Fitness Examination for Supervising Chemical Laboratories (C-14).* (1999). New York City Fire Department.

[6] *Prudent practices in the laboratory. [Electronic resource]: handling and disposal of chemicals.* (1995). Washington, D.C.: National Academy Press.

[7] *Compressed Gas Cylinders*. UCLA Environment Health and Safety

[8] *Hazardous waste disposal guide*. (2015). Northwestern University Office for Research Safety

[9] Safety *in academic chemistry laboratories Volume 1*. (2003). Washington, DC: American Chemical Society.

[10] *Safety in academic chemistry laboratories Volume 2.* (2003). Washington, DC: American Chemical Society.

For more information, suggested readings are;

Furr, A.K. (2000). *CRC handbook of laboratory safety*. Boca Raton: CRC Press.

Hall, S.K. (1994). *Chemical safety in the laboratory*. Boca Raton: Lewis Publishers.

Appendix A. GRADUATE STUDENT ORIENTATION CHECKLIST

Name & Email:
Start Date:
Contact Number:
Supervisor's Name:
Laboratory Used:
Nature of Employment: ☐ Undergraduate ☐ Master Student ☐ PhD Student

LABORATORY ORIENTATION PROCESSES

☐ Laboratory Safety Training has been provided.

☐ Laboratory Safety Manual has been reviewed and understood.

☐ Location of the fire extinguishers, safety showers, eyewash stations, first aid kit and fume hoods are known.

☐ Personal protective equipment requirements in the laboratory have been explained.

☐ Storage, labeling and disposal requirements for chemicals have been explained.

☐ Location of MSDS is known and it is readily accessible.

☐ Location and use of hazardous waste accumulation areas are known.

☐ Location of highly hazardous materials, equipment or processes and their rules for use are known.

- ✓ I understand that it is my responsibility to follow the safety rules.
- ✓ I will wear all personal protective equipment required in the laboratory (long pants, closed-toe shoes, laboratory coat, goggles and gloves).
- ✓ I understand that it is my responsibility and the expectation of my supervisor, the department and the university that I report any injuries, workplace hazards and near misses and ask questions to get help to complete work tasks safely.
- ✓ I will not threaten my own health and safety, or others' by taking unnecessary risks.

Supervisor Signature:	**Date:**

Student Signature:	**Date:**

Appendix B. DOOR SIGN

al University

METU CHEMICAL ENGINEERING DEPARTMENT

ODTÜ KİMYA MÜHENDİSLİĞİ BÖLÜMÜ

RESEARCH LABORATORY

ARAŞTIRMA LABORATUVARI

NO EATING, DRINKING OR SMOKING/ ***YEMEK, İÇMEK VE SİGARA İÇMEK YASAKTIR.***

POTENTIALLY HAZARDOUS SUBSTANCES/ ***POTANSİYEL TEHLİKELİ MADDELER***

AUTHORIZED PERSONNEL ONLY/*SADECE YETKİLİLER GİREBİLİR.*

FOR ANY EMERGENCY CALL
ACİL DURUMDA ARAYIN

METU Ambulance/*ODTÜ Ambulans*: 210 4960

METU Domestic Services/*ODTÜ İç Hizmetler*:210 2704

(off-hours/*mesai dışı:210* 2113)

METU Medical Center/*ODTÜ Sağlık Merkezi*: 210 4960

ROOM/*ODA*:
SUPERVISOR/*DANIŞMAN*:

LABORATORY CONTACT/*LABORATUVAR YETKİLİSİ*:


Appendix C. GLOSSARY [5], [6]

Combustible Liquid: Any liquid mixture, or compound that has an ability to burn at a temperature above 38 ^{o}C (100^{o}F) (e.g. fuel oil).
Corrosive Acid: A substance which may harm people or other substances with contact (e.g., sulfuric, hydrochloric, nitric, etc.).

Explosive Material: A substance that contains a great amount of chemical potential energy that causes explosions
Flash Point: The minimum temperature at which a liquid emits a vapor to form a mixture with air that can be ignited in the presence of an ignition source.
Flammable Gas: A gas that will form an explosive mixture with air.
Flammable Liquid: Any liquid mixture, or compound which will release a flammable vapor at a temperature below 38 ^{o}C and ignite easily and burn with extreme rapidity (e.g., acetone, ethyl alcohol).
Flammable Solid: A solid substance that can potentially induce a fire through friction, or spontaneous chemical change (e.g., sulfur, metallic calcium).
Fume Hood: It is a type of local exhaust ventilation system that is designed to control exposure to toxic, hazardous of flammable vapor or gases.

Gas Cylinder: A pressure vessel used to store gases at high pressures.

Incompatible: Two materials that, when placed in contact, can cause poisonous or flammable gases, explosions, or spontaneous ignition.

Irritants: Non-corrosive chemicals that induce reversible inflammatory effects upon contact such as organic or inorganic compounds or wide variety of chemicals in the form of crystalline or powder.

MSDS (Material Safety Data Sheet): A document that provides guidelines intended to train workers on the hazards and precautions for the chemicals that they will use.

NFPA (National Fire Protection Association): An organization which provides a widely-used classification system for identification of hazardous materials. This system uses a symbol with color and numerical ratings. The color identifies the kind of the hazard and the numbers identify the degree of the hazard.

Oxidizing Material: A substance that provides oxygen readily to support combustion. This increases the chance of fire or explosion (e.g., bromine, chlorates, potassium permanganates, sodium nitrate, and hydrogen peroxide).

Personal Protective Equipment (PPE): Clothes and other body-wear such as safety glasses, googles or gloves, which are worn to protect against hazards.

Sensitizers: Substances that may induce allergic reactions after long-term exposure.

Unstable (Reactive) Chemical: Reactive Materials that are unstable or highly reactive materials that can undergo extremely hazardous uncontrolled reactions (e.g., hydrogen, methane).

Volatile Inflammable Oil: Any oil or liquid that will produce a flammable vapor at a temperature below 38 ^{o}C.