












Introduction to Laboratory Safety

Dr. Mohamed Abdel Salam

Professor Dr. Adullah Y. Obaid

Professor Dr. Shaeel A. Al Thabiti

Chemistry Department

Faculty of Science

King Abdulaziz University

بسم الله الرحمن الرحيم

إن الحمد لله ، نحمده ، ونستعينه ، ونستغفره ، ونتوب إليه ، ونعوذ بالله من شرور أنفسنا ، ومن سيئات أعمالنا ، من يهده الله فلا مضل له ، ومن يضلل فلا هادي له .

وأشهد أن لا إله إلا الله وحده لا شريك له ، وأشهد أن محمداً عبده ورسوله، أرسله الله تعالى بالهدى ، ودين الحق ، فبلغ الرسالة ، وأدى الأمانة ، ونصح الأمة وجاهد في الله حق جهاده ، فصلوات الله وسلامه عليه ، وعلى آله ، وأصحابه ، ومن تبعهم بإحسان إلى يوم الدين"

جاء الإسلام بتعاليمه السمحة، ومبادئه القويمة، ومقاصده العظيمة، ليحفظ للناس دينهم،و أنفسهم و عرضهم و عقلهم و مالهم و لما كانت المحافظة على النفس من المقاصد الشرعية الداعية إلى حفظ الجنس البشرى من أجل عبادة الله سبحانه و تعالى و استعمار الأرض حيث يقول الله سبحانه و تعالى **{ ولا تلقوا بأيديكم إلى التهلكة } البقرة 195 ، و { ولا تقتلوا أنفسكم إن الله كان بكم رحيمًا } النساء 29 و** قال صلى الله عليه و سلم **"لا ضرر و لا ضرار"** و لهذا كان ولابد من تأليف هذا الكتاب الذي يوضح كيفية التعامل مع المواد الخطرة عامة و الكيميائية منه بخاصة و التي تحيط بالإنسان من كل جانب و ليس داخل المعامل فقط.

حرص المؤلفون على وضع خبرة سنواتهم المعملية لتوضح للذين يتحتم عليهم التواجد داخل المعامل كيفية التعرف على الأخطار عامة و كيفية الوقاية منها و التعامل معها في حين حدوثها بحيث يقلل المخاطر والآثار الناتجة عن الحوادث و ذلك وفق المعايير القياسية المحلية و الدولية.

و نسأل الله سبحانه و تعالى أن يحفظكم من كل سوء أو مكروه و يجعل عملنا هذا خالصا لوجه تعالى و يجعلها من صور التعاون على البر و التقوى **{ و تعاونوا على البر و التقوى } المائدة 2 و{ ومن *أحياها* فكأنما أحيا الناس جميعا} المائدة 32.**

المؤلفون

Preface

Today, more than ever, laboratory safety knowledge is essential for both students and employees. Laboratory activities and demonstrations represent an essential part of effective science teaching. Although many science activities present potential hazards, reasonable and cautious safety practices greatly reduce the possibility of accidents. When lab personnel and students adhere strictly to standard safety precautions, they are unlikely to encounter any risks. Knowing about possible hazards and taking precautions are the basis for creating a safe learning environment. In this book, an introduction to the safe laboratory practice is presented in order to protect the future of this nation, which means you and your fellow students. The human life is a sacred in Islam and must away from any harm, either accidentally or intentionally.

We wish a safe and good luck for all of you,

The authors,

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Chapter 1

Introduction

Introduction

At the beginning of this book, it is important to define few terms such as safety, laboratory, hazards and its sources to be aware of them.

What is safety?

The word **safety** is very often used in the everyday life and have different meaning, but in general, it means the quality or condition of being safe; freedom from danger, injury, or damage.

What is laboratory?

A laboratory may be a place of specialized work, research, clinical or diagnostic evaluation, teaching and/or learning. Laboratories are commonly used in many scientific disciplines from chemistry, physics, botany and zoology to medicine, psychology, dentistry, chemical engineering, agriculture and veterinary science. The term laboratory may equate with workshop in engineering areas such as mechanical, electrical, aeronautical and civil engineering.

What is Hazard?

A hazard is generally anything that can hurt you or make you ill, or cause damage.

Laboratory hazard:

The hazards encountered in a laboratory are many and varied. These hazards fall generally into one of five categories:

1. Chemical hazard, such as corrosives, flammables, toxics, explosives,…etc
2. Biological hazard, such as pathogenic microorganisms, biological tissues, animals
3. Physical hazard, such as noise, radiation.

4. Electrical/Mechanical hazard, such as high voltage apparatus, machinery with moving parts.
5. Psychological hazard, such as emotional stress.

Therefore, it is very important before entering any lab to identify the sources of hazard and follow the safety rules to protect yourself and to be sure about your safety.

What is the need for regulation?

Lab safety regulation is very important practice and it is there to do the following;

1. Protect the interests of the instructor and students or any one who is attending a lab course.
2. Safe-guard against loss of life and property.
3. Guarantee individuals right: RIGHT-TO-KNOW (RTK) & RIGHT-TO-BE-INFORMED (RTBI).

Instructors as well as students must be aware of the potential problems in the science classrooms and particularly in laboratories. Science instructors must be the advocates of safety and need to have the information and necessary attitudes to bring appropriate safety standards.

This exercise was also carried out as a quality initiative;

- **To p**revent hazardous situations in science laboratories;
- **To a**dopt reasonable and prudent safety practices;
- **To c**reate a safe working environment; and
- **To i**mprove working conditions in science laboratories

However, the primary list of laboratory safety rules for the science program can be reasonably generic and should include the following:

1. Laboratory working conditions should be safe.

2. Personal protective equipment (PPE) must be of the accepted type for the activity and must be worn correctly at all times by students and instructors.

3. All chemicals and other hazardous materials must be kept in a properly secured area, clearly and appropriately labeled, and accounted for meticulously at all times.

4. Proper equipment and supplies must be provided to students for use. They must be given instructions in laboratory techniques and in handling materials before being allowed to conduct experiments.

5. Instructors must supervise laboratory activities at all times.

6. Emergency telephone numbers appropriate signs including emergency response and evacuation procedures should be conspicuously posted in laboratories.

What do you need to know before starting laboratory work?

Before starting any lab work you should read and follow the general lab rules.

General lab rules:

1. Work in the lab only when the instructor is present or when you have permission to do so.

2. Identify any source of hazards present in the lab and report to the instructor.

3. Learn the location and proper usage of the eyewash fountain, fire extinguisher, safety shower, fire alarm box, office intercom button,

evacuation routes, clean-up brush and dust pan, glass/chemical disposal can.

4. Report all accidents regardless of how minor to your instructor.

5. Before beginning work in lab, clean the lab bench top and your glassware.

6. Never indulge in horseplay or behavior that could lead to injury of others.

7. Use goggles and lab coat when instructed to do so.

8. Read the label on chemical bottles at least twice before using the chemical. Many chemicals have names that are easily confused.

9. Due to the dangers of broken glass and corrosive liquid spills in the lab, open sandals or bare feet are not permitted in the lab.

10. For minor skin burns, immediately plunge the burned area into cold water and notify the instructor.

11. If you get any chemical in your eye, immediately wash the eye with the eye-wash fountain and notify the instructor.

12. Never look directly into a test tube. View the contents from the side.

13. Never smell a material in a test tube or flask directly. Instead, with your hand, "fan" some of the fumes to your nose carefully.

14. Immediately notify the instructor of any chemical spill and clean up the spill as directed.

15. Never take chemical stock bottles to the lab benches.

16. Use equipment only as directed:

a. never place chemicals directly on the pan balances.

b. use glycerin when inserting glass tubing into rubber stoppers.

c. be cautious of glassware that has been heated.

d. add boiling chips to liquid that is to be heated before heating.

e. point test tubes that are being heated away from you and others.

16. Never taste any material in the lab

17. Food, drink and gum are prohibited in lab.

18. Never add water to concentrated acid solutions. The heat generated may cause spattering. Instead, as you stir, add the acid slowly to water.

19. Return all lab materials and equipment to their proper places after use.

20. Upon completion of work, wash and dry all equipment, your lab bench and your clean-up area.

Symbols and Color Codes

Colors and symbols appropriately used can provide ever-present information and warnings of hazards which are essential to safety at work, and in some instances may be independent of language. Those having vision in any way deficient in color perception should take appropriate care where color is used as a sole means of identification.

1- Prohibition Signs should be based on a **red** circular band and red diagonal bar running through the left upper quadrant to the lower right quadrant, with white backing. The symbol for the prohibited action should be shown in black behind the red diagonal bar: for example, 'No Smoking' with a cigarette depicted or no food or drink.

No Smoking

No Food or Drink

2- Information Signs reminding of an essential precaution should comprise a blue disc upon which is superimposed in white a symbol of

the precaution to be taken: for example, 'Goggles to be Worn' with a man's head with goggles depicted. If, exceptionally, no suitable symbol is available, appropriate wording may be used instead: for example, 'Fire escape keep clear'.

3- Warning signs should be based on a yellow triangle bordered by a black band. The symbol for the hazard is depicted in black: for example, poisoning risk with black skull and crossed bones on the yellow background or danger Corrosion risk sign.

4- **Safe Condition sings** give information of a safety nature, which should be shown by words or a symbol in white upon a **green** square or rectangle: for example, a white arrow on a green background points to an emergency exit. The same principle applies to fire-fighting equipment and its location except that the background colour should be red.

5- If there is need to amplify or clarify the meaning of any symbols used in a safety sign or notice, then a supplementary sign with text only (for example, 'Not Drinking Water') should be given below the sign. The supplementary sign should be oblong or square and should either (a) have text in black on a white background or (b) have a background color which is the same as the safety color used on the sign it is supplementing, with the text in the relevant contrasting color.

Color	Red	Blue	Yellow	Green
Type	**Prohibition Signs**	**Information Signs**	**Warning signs**	Safe Condition sings
Meaning	Must not do	Must do	Be caution	**Do it safely**
Example				

What to do before leaving the lab?

Before finishing your work and leave the lab you have to the following:

1- Clean your work area.

2- Return all chemicals, glass wares, instruments…etc, to their original places.

3- Clean your work areas.

4- Remove Personal Protective Equipment (PPE) such as gloves and lab coats.

5- Wash your hands before leaving the laboratory

6- Turn off and unplug hot plates before leaving the lab.

7- Ensure doors are locked when leaving the laboratory.

Chapter 1 Questions

1- Define each of the following terms:

a) Safety

b) Laboratory

c) Hazards

2- Explain what are the different types of hazards could be present inside a laboratory?

3- Why do need to regulate lab safety?

4- Explain different lab rules you should adapt in order to be safe inside a lab?

5- Explain the different symbols and color codes that are used inside a lab?

6- What to do before leaving the lab?

Chapter 2

General Work Practices

The cost of laboratory accidents can be enormous in terms of fatalities, serious injuries, property loss, and the costs of replacing equipment and repairing or rebuilding laboratories. For that reason, any one present within a laboratory, should know how to work safely with hazardous materials and how to create and design a hazardous-free and safe area and procedure for work inside the laboratory.

Before starting lab work

Every laboratory worker should observe the following rules:

1. Know the potential hazards and appropriate safety precautions before beginning work. Ask and be able to answer the following questions:

What are the hazards?

What are the worst things that could happen?

What do I need to do to be prepared?

What work practices, facilities or personal protective equipment are needed to minimize the risk?

2. Know the location and how to use emergency equipment, including safety showers and eyewash stations.
3. Never block safety equipment or doors and keep aisles clear and free from tripping hazards.
4. Familiarize yourself with the emergency response procedures, facility alarms and building evacuation routes.
5. Know the types of personal protective equipment available and how to use them for each procedure.
6. Be alert to unsafe conditions and actions and bring them to the attention of your supervisor or lab manager immediately so that corrections can be made as soon as possible.
7. Prevent pollution by following waste disposal procedures. Chemical reactions may require traps or scrubbing devices to prevent the release of toxic substances to the laboratory or to the environment.
8. Position and clamp reaction apparatus thoughtfully in order to permit manipulation without the need to move the apparatus until the entire

reaction is completed. Combine reagents in the appropriate order and avoid adding solids to hot liquids.

What makes some materials hazardous?

Chemicals and chemical safety and awareness don't belong only in the laboratory anymore. Chemicals are everywhere and we use them in a variety of ways. Just look at the shelves in your home--the kitchen and bathroom shelves boast a variety of chemicals. Everything from deodorant to oven cleaner to plant food contains chemicals. Most of these when in significant concentrations may even be termed hazardous. Most of us have little or no difficulty working safely with these hazardous substances, but the more information we have, the safer we can be.

1- Toxic

Most chemicals are toxic at some level of exposure. If allowed to enter the body through the nose, mouth, or skin they can make you sick. Fumes, dusts, and vapors from toxic materials can be especially harmful because they can be inhaled and pass quickly from the lungs into the blood, allowing the poisons to circulate throughout the body.

2- Corrosive

Materials, such as strong acids and bases, can eat completely through other substances including your clothing. If splashed on the skin or eyes, they can cause serious burns. Some of these break down into poisonous gases making them doubly hazardous.

3- Explosive

Some materials can explode when they are exposed to heat or flame. Included in this category are materials such as flammable liquids and compressed gases, which can explode under certain conditions.

4- Flammable

This category includes all materials that catch fire easily, burn rapidly, spread quickly, and give off

intense heat. Many materials used and stored in the workplace are flammable, including solvents and lubricants.

5- Reactive

These materials have to be isolated, stored in special containers, and used with extreme caution. Some can burn when exposed to air or water, some when mixed with other substances. It is important to note that reactive materials do not have to be near heat or flames to burn. They burn spontaneously. They can also give off vapors that can be harmful if inhaled.

As a matter of good practice, and to satisfy regulatory requirement, particularly hazardous substances require additional planning and considerations. A list of particularly hazardous substances is available in Appendix A of this book. This list does not include all chemicals and you must consult the material safety data sheet to determine whether a particular chemical may be considered a carcinogen, reproductive hazard or substance with a high acute toxicity.

The USA Occupational Safety & Health Administration (OSHA) Laboratory Standard defines particularly hazardous substances as:

- **Carcinogens** which are the substances capable of causing cancer such as asbestoses, benzene and cadmium. Carcinogens are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may become evident only after a long latency period**.**

- **Reproductive Toxins** which are a substances that have adverse effects on various aspects of reproduction, including fertility, gestation, lactation, and general reproductive performance such as Dimethyl formamide (DMF) and Hydrazine. When a pregnant woman is exposed to

a chemical, the fetus may be exposed as well because the placenta is an extremely poor barrier to chemicals. Reproductive toxins can affect both men and women. Male reproductive toxins can in some cases lead to sterility.

- High Acute Toxicity Substance which includes any chemical that falls within any of the following OSHA-defined categories:

- A chemical with a median lethal dose (LD_{50}) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD_{50} of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

Designated Areas

Any area where particularly hazardous substances, including carcinogens, acutely toxic chemicals and reproductive toxins, are stored or used must be posted as a **Designated Area.** These materials should be stored separately from other chemicals, as space permits.

Chemical Safety Plan

The following represents very crucial points that should be considered when working with any hazardous chemicals inside the laboratory.

1. **Responsible behavior in the laboratory is essential.** The dangers of spilled acids and other chemicals, as well as broken glassware created by thoughtless actions, are too great for irresponsible behavior to be tolerated.

2. **Perform no unauthorized experiments.** Use only the quantities of reagents as instructed in written procedures, and no more. Consult your instructor if you have any doubts about the instructions in the laboratory manual or written procedure. Prior approval should be obtained from the supervisor/instructor whenever a new laboratory procedure, test or experiment is carried out, or there is a change in an existing procedure, test or experiment. Also, when planning laboratory experiments or procedures involving chemicals, consult this plan to acquire information about specific hazardous substances used in ISAT laboratories. Additional information concerning all chemicals-as potential hazards, safety issues when handling and disposing of them, and steps to take in case of accidental release (e.g., spill, leak)-is contained in the computerized MSDS collection for ISAT. Knowledge of this type of information should be in hand BEFORE the experiment is started.

3. **Working alone in the laboratory is not permitted.** At least one other person should be present in the same room, and an instructor should be readily available.

4. **Think about what you are doing in the laboratory.** Plan ahead; do not "cookbook." If you give no thought to what you are doing, you predispose yourself to an accident.

Lab Apparel

1. Wear approved eye protection - where and when chemicals are handled or there is a possibility of injury to the eyes because of ongoing laboratory procedures (e.g., from projectiles, from boiling water.)

a. Eye protection should protect against impact and chemical splashes. Goggles, or other special eye protection, must be worn by those who already wear prescription glasses.

b. If your eyes come into contact with an acid, alkali, abrasive or otherwise irritating substance, wash your eyes with flowing water from a

sink or eyewash station for at least 15 minutes. Seek medical attention immediately.

2. Footwear that completely covers the feet is required, because of the danger of broken glass and the possibility of chemical spills.

3. A lab apron or coat must be worn

- when you are wearing easily combustible clothing, such as synthetic and light fabrics
- when working with and/or transporting hazardous chemicals

4. Gloves should be worn when working with hazardous chemicals. These gloves should be made of material known to be resistant to permeation by that chemical. Inspect gloves before each use, wash them before removal, and replace them periodically.

Chemistry Lab Policies

1. As part of the **safety orientation** to the lab, you will be shown the location of fire extinguishers, fire blankets, safety showers and fire alarms. In addition, you will be informed of the location of MSDS, and shown how to use them. <u>All laboratory workers and students should know</u>

- the hazards of a chemical as stated in the MSDS and other appropriate references pertaining to that chemical
- the location and proper use of emergency equipment
- how and where to properly store chemicals when not in use
- the proper method for transporting chemicals within the department
- the appropriate procedures for emergencies, including evacuation routes, spill cleanup procedures and proper waste disposal

2. **In case of fire or accident**, call the instructor at once. Be aware that wet towels can be used to smother small fires. Use any apparatus available to put out or contain a fire.

3. **In case of the chemical spill on your body or clothing**, wash the affected area with large quantities of running water. Remove clothing that has been wet by chemicals to prevent further reaction with the skin.

4. **In case of accidental ingestion of a chemical**, try to drink large volumes of water.

5. **Promptly clean** all chemical spills and **properly dispose** of spilled chemical and cleanup material

6. **Properly label and store all chemicals and equipment**. All chemicals (including solutions and chemicals transferred from their original containers) should be labeled with their names, concentrations and hazards.

7. **Do not eat or drink anything, do not chew gum, do not smoke, and do not apply cosmetics** in the laboratory. In addition, since many chemicals are absorbed through the skin, avoid direct skin contact. If you suspect skin contact with chemical substances, such as bottled reagents, wash off these substances with large quantities of water. Wash your hands thoroughly with soap and water before leaving the laboratory. In addition, do not store or handle food or beverages in laboratory areas, including refrigerators used for chemical storage.

8. **Report all injuries to your instructor at once**. Except for very superficial injuries, you will be required to get medical treatment for cuts, burns, or fume inhalation.

9. **Avoid deliberately and directly breathing fumes of any kind.**

a. To test the smell of a vapor, with your instructor's permission, collect some of the vapor in a cupped hand.

b. Work in a chemical fume hood if there is the possibility that noxious or poisonous vapors may be produced.

10. **Do not use mouth suction to fill pipettes** with water or chemical reagents, aqueous or organic. Always use a suction device provided.

11. **Confine long hair and loose clothing** in the lab, since either can catch fire or be chemically contaminated.

12. **Keep your work area neat at all times.** Clean up spills and broken glass immediately. Clutter not only will slow your work, but it leads to accidents. Clean your workspace, including wiping the surface and putting away all chemicals and equipment, at the end of the laboratory preparation, course laboratory period or student project session.

13. **Be careful when heating liquids**; add boiling chips or beads to avoid "bumping." Flammable liquids such as ethers, hydrocarbons, alcohols, acetone, and carbon disulfide must not be heated over an open flame.

14. **Always carefully and slowly pour** acids into water when mixing to avoid spattering.

15. **Do not force a rubber stopper onto glass tubing or thermometers.** Lubricate the tubing and the stopper with glycerol or water. Use paper or cloth toweling to protect your hands. Grasp the glass close to the stopper.

16. **Dispose of excess liquid reagents** by flushing small quantities down the sink. Discuss with the instructor about disposing of large quantities. Dispose of solids in approved containers. DO NOT RETURN REAGENTS TO THEIR ORIGINAL CONTAINERS.

17. **Properly label and store all chemicals and equipment.** All chemicals (including solutions and chemicals transferred from their original containers) should be labeled with their names, concentrations and hazards.

18. **Do not block access to emergency equipment or exits.**

19. **All chemicals and wastes should be placed in their proper storage area at the end of the day.**

20. **All working surfaces and floors should be cleaned regularly.**

21. **Laboratory doors leading to hallways are to be closed during any laboratory activity.**

22. **Glassware:**

• Do not use broken, chipped, starred or cracked glassware.
• Clean all glassware after use.
• Do not pick up broken glassware with bare hands. Use gloves or sweep it up. Deposit broken glass in a "Broken Glass Safety Toss Box."
• Handle hot glassware with proper size and type of tongs or hot mitts.

23. **Vacuum and pressurizing equipment and materials:**

• Use a safety shield whenever an implosion might occur when working with vacuum equipment. Shield or wrap Dewar flasks or other evacuated glass apparatus.
• Use steam or heating mantles to heat vacuum distillation flasks.
• Relieve vacuum in all parts of system before opening apparatus. Relieve vacuum slowly. Avoid sudden pressure changes which could cause breakage or spattering of contents. Do not relieve vacuum on heated apparatus until apparatus has cooled.
• Use a safety shield whenever an explosion might occur when working with pressurizing equipment.
• Do not apply pressure to glassware.
• Vent pressure in all parts of the system before opening.

24. **Compressed gases:**

• Store and transport compressed gas cylinders with the safety caps on.
• Transport large cylinders on a hand truck to which the cylinder is secured.
• Cylinders should be clamped securely to a wall or other firm support with an appropriate cylinder clamp or chains.
• Always use a reducing valve with gas cylinders.
• Do not lubricate, modify or tamper with a cylinder valve.
• Do not heat cylinders or store them near a heat source.

Standard Operation Procedures

Standard Operation Procedures (SOPs) are common procedures in most laboratories which insure the proper and efficient work. SOPs relevant to

safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals. SOPs generally deals with the followings:

1. General Laboratory Safety Procedures
2. Procedures for Proper Labeling and Safe Storage of Chemicals
3. Chemical Fume Hood - Procedures for Proper and Safe Use
4. Corrosive Chemicals - Procedures for Safe Handling and Storage
5. Flammable and Combustible Liquids - Procedures for Safe Handling and Storage
6. Oxidizing Agents - Procedures for Safe Handling and Storage
7. Reactive Chemicals - Procedures for Safe Handling and Storage
8. Carcinogens, Reproductive Toxins, and Acutely Toxic Chemicals - Procedures for Safe Handling and Storage
9. Compressed Gases - Procedures for Safe Handling and Storage
10. Cryogenic Liquids - Procedures for Safe Handling and Storage
11. Electrical Safety Procedures
12. Glassware and Sharps - Procedures for Safe Handling and Disposal
13. Chemical Spill Response Procedures

Appendix II explains the SOPs relevant to safety and health that should be followed inside chemistry laboratories.

Chapter 2 Questions

1- What do you need to know before starting any lab work?

2- What makes some materials hazardous?

3- How many classes could any chemical categorized? Give examples.

4- Explain how the different type of hazards could any chemical poses, according to USA Occupational Safety & Health Administration (OSHA) Laboratory Standard?

5- Define the designated area? Give examples?

6- What are the crucial points you should consider when you work with hazardous material inside a laboratory?

7- Define lab apparel and mention its parts?

8- What should you do in the cases of:

a) fire

b) chemical spill

c) accidental ingestion of a chemical

d) injuries

e) chemical waste

9- Explain how you could work safely with the following:

a) Glass ware

b) vacuum and pressurizing equipment and materials

c) compressed gases

10- Define Standard Operation Procedures? Give examples?