To close the yellow note, click once to select it and then click the box in the upper left corner.
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#10 Introduction to the Chemistry Lab: Safety Comes First

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INTRODUCTION

Description

Students will have the opportunity to gain a hands-on approach to safety in the laboratory. Included in this experiment is a list of the chemistry department laboratory safety rules to act as a guide for answering questions. Students will locate the safety items in the laboratory and draw a layout. They will also have the opportunity to try out the safety devices in the laboratory. Students will become familiar with Material Safety Data Sheets (MSDSs) and will extract data relating to the hazards of various chemicals that they will be using in upcoming experiments.

Student Audience

This experiment is adequate for high school students as well as first-year college students.

Goals for the Experiment/Activity

- Review list of chemistry department safety rules.
- Locate and know how to use safety equipment in laboratory.
- Become familiar with Material Safety Data Sheets.
- Stress importance of correct eye protection.
- Learn to respect chemicals and handle them properly.
- Stress importance of correct glove protection.

Recommended Placement in the Curriculum

The recommended placement for this experiment is during the beginning of the school year. It should be run prior to any other laboratory experiment to ensure proper handling of chemicals in future experiments.

Each unit begins with background material and information that the student should read prior to coming to lab. It is followed by an experimental procedure portion such that the student can read over what is expected from them in the laboratory. The last portion of the unit is for the questions. Pre-laboratory questions are given to allow the student to think about what they will be doing in the lab. It is in the pre-laboratory questions where I allow the students to examine relative hazards of the experiment. In this case, however, they will utilize their booklet *"Working Safely with Chemicals"* to find some of the answers. The in-laboratory questions are filled in during the laboratory session, while the post-laboratory questions allow the students to reflect on what they did.

Demonstrations

A. Demonstration with Safety Goggles

Materials needed: various safety glasses and goggles. Several different types of eye protection will be put on display. Discussion will include which type would be most beneficial in a chemistry laboratory.

B. Demonstration with egg whites, nitric acid, and disposable contact lenses

Materials needed: egg whites, nitric acid, disposable contact lenses, visualizer, eye dropper, petri dish.

Egg white containing protein (simulates eye) is placed in petri dish on visualizer. A drop of nitric acid is put on egg which shows immediate yellow (nitrates). Contact lens is placed on egg white and drop of nitric acid is placed on it – contact will start to disintegrate leaving only a little shield over the egg, which would act as a barrier for quick water relief to eye.

C. Demonstration with ether

A small amount of ether is poured onto lab bench (no other flammables nearby).
A match is lit away from the lab bench (lower than bench since ether vapors will sink).
Ether and vapor will ignite demonstrating that vapors of some chemicals are flammable.
(Most students think "just don't get the flame on the chemical.")

Assessment

This unit is assessed by reviewing the responses on the Question pages. Each question or activity clearly states how many points are available for the response. A semester consists of 15 experiments worth 20 points each with this unit being one of them.

STUDENT HANDOUT

Introduction to the Chemistry Lab: Safety Comes First

Purpose

To learn the basic safety rules in the lab, to learn the use of appropriate safety devices and PPE, and to learn how to use the Material Safety Data Sheets.

Scenario/Industrial Applications:

Various types of chemicals are used in a large number of industries, chemical/fertilizer plants, hospitals and research laboratories; therefore, it is extremely important to learn the basic safety rules for chemistry labs which in principle are to be also observed while working in any work place. No matter what type of position you accept after school - **Safety needs to be the number ONE priority!**

Compliance with the law mandates that **Material Safety Data Sheets (MSDSs)** will be made available in each employment setting. Employees have the **"Right to Know"** exactly what chemicals they will be working with and information about them. Material Safety Data Sheets are commonly referred to as MSDS sheets and provide concise information about the hazards of the materials you will work with. This information will allow you to protect yourself and will inform you on how to respond to an emergency situation if one should arise. Information obtained from the MSDSs is detailed in the *"Working Safely with Chemicals in the Laboratory - 2nd Edition."* You will be expected to read about the hazards of the chemicals you will be working with prior to coming to the laboratory. This is for your own benefit as well as the rest of the people in the laboratory!

For any laboratory to be a safe environment, the person must make sure that he/she is **wearing the appropriate personal protective equipment (PPE)** which includes: splash goggles, coveralls, lab jackets, aprons, gloves, respiratory equipment, boots, shields, etc. Since chemicals may enter your body in a variety of ways (inhalation, ingestion, skin absorption and/or eye contact), it is critical to protect your body by using a variety of equipment. Depending upon what chemicals are being used, one should commonly wear splash goggles, an apron or a lab coat, and chemical resistant gloves. If there's even a slight chance that an implosion or an explosion may take place, a face shield or safety shield may be appropriate. In some of the advanced labs, respiratory equipment may be necessary for work with various chemicals that are toxic if inhaled. Fume hoods with adequate ventilation are sufficient for the work that will be done in the beginning labs. **Always think SAFETY FIRST and protect yourself.**

It is critical before beginning *any* chemistry laboratory experiment to know how to safely handle the equipment and chemicals that are going to be used and to realize the potential hazards that exist. It is imperative to pay attention to proper use of equipment and chemicals in each experiment. This requires reading over the experiment directions and completing the pre-laboratory assignment **before coming to the pre-lab lecture** and following the directions as given in the pre-lab.

Each chemical has a **National Fire Protection Agency** (**NFPA) Hazard Rating** which addresses the hazards of a material which may exist due to short-term, acute exposure caused by an emergency such as a spill. This rating system address the **health (blue), flammability (red), reactivity (yellow), and special hazards (white)** associated with each chemical. The NFPA

label consists of four diamonds in one and is illustrated in Figure 1. A numerical value of 0 indicates that there is no hazard associated with the chemical. As the numbers increase, the hazard level increases. A numerical value of 4 indicates that the chemical is extremely hazardous and has attained the maximum hazard rating.

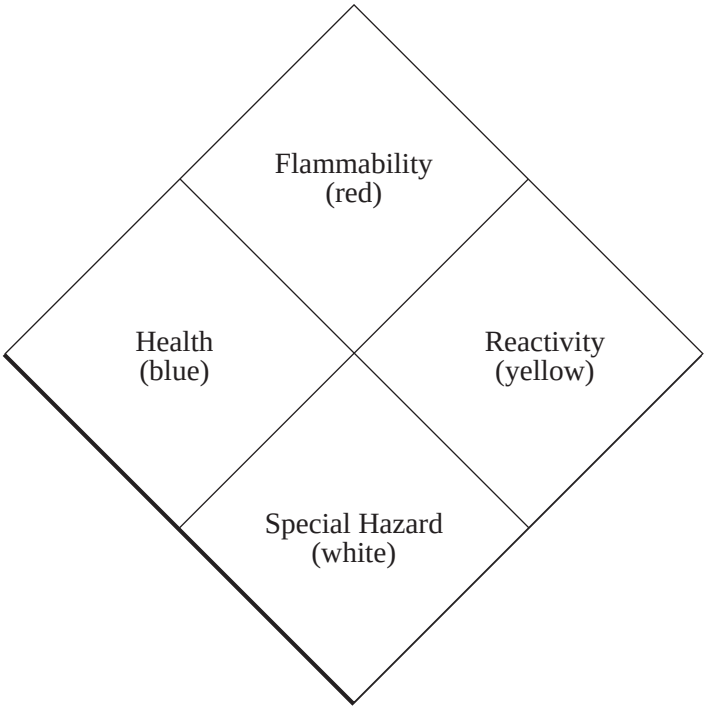

Figure 1.

A summary of the numerical ratings for each:

Flammability - susceptibility to creating flames
- 0 = not flammable
- 1 = ignites when preheated
- 2 = ignites when moderate heat exists
- 3 = ignites easily
- 4 = very flammable, ignites very easily

Health - a measure of health hazard
- 0 = relatively nonhazardous
- 1 = slightly hazardous
- 2 = hazardous
- 3 = very hazardous
- 4 = extremely hazardous

Reactivity - a measure of stability
- 0 = very stable, unreactive with water
- 1 = unstable when heated
- 2 = chemical may change
- 3 = may detonate when heated
- 4 = very unstable, may detonate

Special Hazard - any particular cautions
- ~~W~~ = water reactive
- OX = oxidizer

Safe handling of chemicals should not end when the experiment is over. All chemicals are to be disposed of in appropriate containers as demonstrated in pre-lab lecture and/or by your laboratory room instructor. **Mixing wastes is not only expensive in terms of disposal, but may also be dangerous.**

Of course, even when we act in the appropriate manner, accidents can and do happen. It is therefore critical not only to know how to prevent them but also how to respond to an accident when one does occur.

Safety, Handling, and Disposal:

In this experiment, the most important portion in working the safety showers is to verify that the appropriate water container is under the shower prior to pulling the cord. Do not pull the fire extinguisher plug when examining the information card attached to it. There are no hazardous wastes associated with this lab.

In addition to reading about the hazards of the chemicals you will be working with, it is imperative that you adhere to some basic laboratory safety rules. The chemistry department has adopted a list of the major points that must be strictly adhered to. Failure to abide will result in dismissal from the laboratory and possible disciplinary action.

CHEMISTRY DEPARTMENT LABORATORY SAFETY RULES:

Personal Precautions

1. **Wear appropriate Personal Protective Equipment (PPE).**

a. Approved eye protection is to be worn in the laboratory at all times. Approved eye protection means **splash goggles**, which protect against both impacts and splashes. Contact lenses must not be worn in the laboratory.

b. Chemical resistant **gloves** should be worn when handling hazardous chemicals.

c. **Aprons** and **lab coats** are strongly recommended.

2. **Dress appropriately for lab.**

a. Closed-toe shoes are required.

b. Loose clothing and ties should not be worn or should be worn under a lab coat.

c. Long hair is to be tied back.

d. Halter tops and shorts should not be worn in the laboratory.

3. Do not prepare, store (even temporarily), or consume food, beverages or gum in the laboratory, or consume anything from laboratory glassware.

4. Smoking is strictly prohibited in the science building.

5. Read to understand the experiment before attempting it. Ask instructor to explain any unclear instructions.

6. Maintain a neat work area.

7. Pregnant individuals may need to take extra precautions and should inform instructor as soon as possible.

Safety at the Bench

1. There is to be **no horseplay** in the laboratory.

2. Chemical reactions are not to be carried out while alone in the laboratory. Only experiments authorized by a faculty member are to be performed.

3. Great care is to be exercised in noting the odors. Breathing vapors of any kind is to be avoided. Transfer of volatile and/or noxious solvents are to be done in a hood.

4. **Never** use flammable liquids near an open flame.

5. A suction bulb is to be used when filling a pipet. Do not insert the bulb onto the pipet but rather gently place it on top for rapid removal of the bulb. **Never** pipet a solution by mouth suction.

6. All chemical wastes are to be disposed of properly. Broken glass belongs in its own marked waste container. Do not mix wastes.

7. Use common sense, e.g., do not leave papers near lit burners.

Anticipating an Emergency

1. **Become thoroughly acquainted with the location and use of safety facilities** such as safety showers, eyewash fountains, fire extinguishers, fume hoods, emergency telephones, broken glassware containers, spill kits (if available), and exits.

2. Become familiar with the hazards of the chemicals being used, and know the safety precautions and emergency procedures before undertaking any work. **Before using any chemical, it is important to read and heed the NFPA label and MSDS sheets.**

Handling an Emergency

1. **All accidents**, no matter how small, **must be reported** to the laboratory instructor.

2. **Spills** are to be reported to the instructor for immediate cleanup using proper techniques. Proper personal protective equipment (PPE) must be worn by the individual cleaning up the spill. Inform instructor of the identity of the spill. Depending on the extent and type of spill, the instructor will evacuate the area and then proceed to isolate and contain the spill prior to the cleanup. It is important not to re-enter the area until the spill has been properly taken care of.

3. **Accidents and Injuries:**

Cuts are to be washed with water and reported to the instructor. Major cuts or other serious occurrences are to be seen by a medical professional.

Burns are to be treated with ice water or cold tap water. Ointment is not to be applied. Serious burns are to be seen by a medical professional.

4. **Splattering of chemicals:**

i. **In the eyes:** Guide victim to eye wash fountain, force eyes open, apply copious amounts of water for at least 15 minutes. Allow the person to get appropriate medical attention.

ii. **On the skin:** The affected area is to be washed with copious amounts of water. Soaked clothing should be removed immediately. For acid splatters, apply sodium bicarbonate; for base (alkali) splatters, apply boric acid; the affected area is to be washed again with water. For serious spills, the victim is to be seen by a medical professional.

iii. **If there is a fire**, students and others are to be evacuated from the area. Anyone with burning hair or clothes is to be showered with water - medical personnel should be called immediately. The fuel supply of the fire is to be shut off. If the fire is not large, use a fire extinguisher directed at the base of the fire and sweep back and forth to put it out. If the fire is large, sound fire alarm and evacuate the building.

Materials Needed

- safety eye wash stations
- safety shower
- pail to collect water from shower
- first-aid kit
- MSDS book and/or computer with internet hook-up
- accident card (1 per team of 2 students)

Procedure

Work in pairs. Write own reports.

Step 1: Complete pre laboratory questions 1-4 before coming to lab.

Step 2: Locate each of the safety items in the laboratory. Draw a layout of the laboratory in response #5 and answer questions #6-7.
(Safety items may include: fire extinguishers, fire alarm, nearest telephone, emergency numbers, safety showers, eye wash units, exits, broken glass container, first aid kits, fire blankets, gas shut-off valve, etc.)

Step 3: Test out safety eye wash unit and safety shower. Be sure that pail is under the shower prior to pulling the cord and that the safety cap is returned to the eye wash after use.

Step 4: Obtain an “accident card” from the instructor. Using the MSDS book and/or internet search and your safety guide, as well as any chemical knowledge that you may already have, answer question #8. The accident card is to be returned to the instructor after use.

Step 5. Identify safety violations on the laboratory sketch in question #9.

Step 6. Finish questions 1-14.

Pre-Laboratory Questions:

1. What do you do if you spill a tiny amount of hydrochloric acid on your hand?
   Hint: Acids are corrosive.

2. What do you do if you get a small cut from a piece of glassware?

3. What information is given on a Material Safety Data Sheet?

4. Define the following hazard warnings commonly found on reagent bottles and give an example of a chemical with each hazard.

a. 

b. 

c 

d. 

e. 

f. 

IN-LABORATORY QUESTIONS:

5. Draw a map layout of the lab to show location of the safety devices. Be sure to label each item and show its location in the lab.

6. The date that the fire extinguisher was last examined is _____.

   Why is it necessary to check this date on a regular basis?

7. What items are found in the first-aid kit?

8. a. My "chemical accident" was:

   b. According to the MSDS for this chemical, the hazards are:

   c. The appropriate response for this is:

9. Identify at least eight safety violations in Figure 2.

POST-LABORATORY QUESTIONS:

10. List at least three precautions **you** will take in the lab to avoid contributing to a fire.

    a. _____

    b. _____

    c. _____

11. Why is it necessary to report **all** accidents to the instructor?

12. List optimum clothing, shoes, and hair arrangement for this class.

13. Discuss the dangers of putting food, pop, coffee, pencil erasers, or similar things in your mouth in this classroom or laboratory.

14. Discuss the role of splash goggles and contact lenses in this classroom and laboratory.

Suggested Reading:

Gorman, Christine E.; "Working Safely with Chemicals in the Laboratory, 2nd Edition"; Genium Publishing Corporation: New York, 1996, pp 20-45.

"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals"; National Academy of Sciences, National Academy Press: Washington D.C., 1995.

NIOSH Pocket Guide to Chemical Hazards (NPG), June 1994, www.cdc.gov/niosh.npg.html

http://www.phys.ksu.edu/~tipping/msds.html

INSTRUCTOR NOTES

Introduction to the Chemistry Lab: Safety Comes First

Time Required: 1 hour, 35 minutes

Group Size: 24 people/laboratory

Materials Needed for Experiment:

- safety eye wash stations
- safety shower
- pail to collect water from shower
- first-aid kit
- MSDS book and/or computer with internet hook-up
- accident card (1 per team of 2 students)

Materials Needed for Demonstrations:

- 2 mL ether
- box of matches
- variety of types of safety glasses and goggles
- visualizer (similar to an overhead projector)
- egg whites
- nitric acid with dropper
- sodium bicarbonate
- disposable contact lenses (optional)

Safety, Handling, and Disposal:

A. Demonstration with Ether - Caution with storing can of ether away from flammables. By pouring about 2 mL, there will be no waste to dispose of.

B. Demonstration with Nitric Acid - Dispose of excess acid by neutralizing with sodium bicarbonate and then washing down the sink. Egg whites may need to be neutralized depending on amount of acid placed on them, disposal in waste.

C. Handling of safety shower - verify large pail in appropriate location to catch water, may need to have a mop readily available in case a student misses the tub. Know where shut off valve is in case safety shower does not shut off.

Points to Cover in Pre-Lab Discussion:

A. Safety Demonstrations:

1. Show flammability of vapors to students. Be sure countertop is strong prior to doing this and that all flammables are away from demonstration. Dim lights. Pour 2 mL ether on center of countertop and light a match away from the ether. Starting at a point lower than the ether, rise the burning match up toward the ether. Vapors will ignite prior to contact allowing students to view the flammability of vapors.

2. Show value of safety goggles with acid in eye demonstration from Flinn Scientific. Place an egg white in a petri dish on a visualizer (instrument used to enhance viewing for a large lecture room). Dropwise, add nitric acid to the egg white which contains protein (simulating eye). Damage is immediate. Disposable contact lenses have also been placed on egg whites which will show signs of disintegrating when touched by the nitric acid. The little shield of contact lens over the egg would demonstrate a barrier for quick water relief to eye.

3. Demonstration with Safety Goggles - variety of safety glasses and goggles are shown to the students. Discussion includes benefits of all (if any) and leads to which type would provide the most protection for a student in a chemistry laboratory setting.

B. Experimental Considerations:

1. Review list of safety rules to reinforce them. Safety rules are listed in experiment.

2. Review meaning of MSDS. Have a sample MSDS available and go through the main points of one. Explain the accident cards - 1 per team of 2 people. Each person should write their own response. Accident cards are to be returned to the instructor for use with other classes.

3. Accident and Injury Reporting - Stress importance! All accidents, no matter how big or small are to be reported to the instructor.

4. Discuss Personal Protective Equipment (PPE) and the laboratory safety devices along with the correct uses of each. This includes: splash goggles, lab aprons and/or jackets, safety shields, respirators, safety showers, eye washes, fire extinguishers, personal, fume hood, broken glass containers, etc.

5. Discuss safety violations and have a policy in place for students that do not adhere to the rules! Policy should also be discussed prior to stepping into the lab.

Procedural Tips and Suggestions:

Allow students to start at any point in the experiment to prevent back-ups in an area. For example, one team may be testing the eye wash, while another team is doing the “accident card.”

Have a number of books of MSDSs available or at least a few computers with internet hook-up available to prevent long lines.

Maintain a mop near the safety shower. Tell students to just give one quick pull on the cord, rather than pull for a long period of time.

Sample Results (for accident cards)

A student is carrying out an experiment and pours HCl instead of H_2SO_4 into his beaker. After realizing the mistake, he wishes to pour the unused **Hydrochloric Acid** back into the reagent bottle, unfortunately he misses and pours it onto the lab bench.

I.B. Klutz is attending his very first chemistry class. He is anxious to get started and decides to do a couple of experiments at the same time for the sake of efficiency. One part of the experiment utilizes the Bunsen burner while the other part uses **Methyl Alcohol**. I.B. misses the beaker when pouring the methanol and a small amount is on the counter next to the open flame.

S.S. Spill is a graduate student in chemistry. She drops a full reagent bottle of **acetic acid** onto the floor. There are many other graduate students also in the lab at the time. A notable amount lands on the arm of one of the students.

I.M. Late is a student notoriously late for lab each week. She often brings her dinner with her since she is taking way too many credit hours. Without realizing it, a few drops of the **sodium hydroxide** she had been working with lands on her sandwich. She proceeds to finish the experiment and then her sandwich.

I.M. Kemist is a senior finishing up a degree in chemistry. She is working in a research lab and finds herself spilling **concentrated sulfuric acid** on her jeans. Fortunately, it is only a few mL of liquid (a small amount) that has landed on her.

An unfortunate student in class has **30% hydrogen peroxide** spilled onto her hand. Having read about the lab prior to class, she acts in the correct manner.

Joni quickly makes up 100 mL of a **sodium carbonate solution**. Having a glass of water nearby, Joni mistakenly picks up the beaker containing sodium carbonate solution instead of her water and proceeds to drink the entire amount.

Joe Cool swiftly gets a whiff of **hydrochloric acid**. He then proceeds to spill some on his shirt. Not wanting anyone to know of the mishap, he decides it is best not to inform the instructor and laboratory assistant.

Jamie drops the reagent bottle of **calcium chloride** onto the floor. Not wanting the instructor to know, he quickly scoops it up with his hands and puts it in the garbage container.

One of the top students decides to help the instructor clean up after a demonstration. Unfortunately he inhales the dry ice (**carbon dioxide** solid).

The laboratory assistant is in the balance room cleaning up some spilled **potassium aluminum sulfate** from the bench. She instantly notices that she has some of the solid on her hands.

One of the students in class obtains a cut from a broken piece of glassware. He goes over to the reagent shelf and obtains the bottle of **elemental iodine** to put on the cut. He does this without consulting any of the instructors.

I.M. Kemist decides to taste the **ferric chloride**. Fortunately he is conscious after tasting this chemical. He then admits to the instructor what he has done.

A bottle of **sodium chloride** spills onto the floor. The laboratory assistant efficiently cleans up the spill and dumps the contaminated sodium chloride into the regular garbage container. She clearly has gotten some of this chemical on her hands.

Alyx did not make it to class for the safety lesson and thus missed out on hearing the importance of safety goggles. While working with **ethyl alcohol**, a notable amount splashed up and landed in her left eye. Her right was not hit by this chemical.

Molly trips in lab while carrying a bottle of **Ethyl Alcohol**. Unfortunately, the bottle breaks and the liquid comes in contact with a Bunsen burner that is lit. The instructor is not present in the room at the time of the accident.

There has been a major chemical spill in the science building. **Ammonium thiocyanate** is all over the floor in the laboratory. Fortunately, no one gets the chemical on their skin. The whole class looks on in amazement.

Plausible Answers to Student Questions:

1. Treat with cold tap water. Report to instructor immediately. Serious burns are to be seen by a medical professional.

2. Wash with water and report to instructor. Major cuts are to be seen by a medical professional.

3. MSDS provide concise information about the hazards of the materials you work with so that you can protect yourself and respond to emergency situations.

4. a. Substance is harmful to food items. Dangerous to ingest.

   Example: Most chemicals, methanol, ether, acetone, etc...

b. A liquid or solid that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact or a liquid that causes a severe corrosion rate on steel or aluminum.

Example: HCl

c. A substance that yields oxygen readily to cause or enhance the combustion of organic matter - a significant hazard in a fire - contact may cause burns.

Example: Nitric acid, silver nitrate, potassium nitrate

d. Can be ignited easily and when ignited, burns so vigorously and persistently as to create a serious hazard - flash point of not more than 141°F.

Example: Acetone, benzene, ethanol

e. Material other than a gas known to be so toxic to humans or cause such extreme irritation as to afford a hazard to health.

Example: Aniline, chloroform, phenol

f. A material that by contact with water becomes spontaneously flammable or gives off a toxic gas and presents a health hazard.

Example: Sodium, potassium, white phosphorus

5. Drawing should include all exits, safety showers, eye washes, first-aid kits, fire blankets, nearest telephone, fume hoods, broken glassware containers, etc.

6. Fire extinguisher should be checked on a regular basis. Used extinguishers need to be recharged.

7. Items in first-aid kit should include: gauze, band aids, etc.

8. Varies, see appropriate MSDS for response.

9. a. flammable liquid near flame
   b. unnecessary clutter on floor
   c. high-heeled shoes
   d. drips on floor
   e. food and beverage in lab
   f. waste reacting - not in hood
   g. hair - not tied back
   h. spilled liquid on counter
   i. garbage on counter
   j. bottles without labels
   k. no goggles (eye protection)

10. a. Clear work space of all flammables when using flames
    b. Tie long hair back.
    c. Don’t wear blousy sleeves.
    d. Know how to use safety devices.
    e. Know locations of safety devices.

11. It is necessary for instructor to make sure that the correct treatment for all accidents and injuries is followed. The instructor will assist students in proper procedures.

12. Optimum clothing in lab includes: jeans, closed-toe shoes, hair tied back. Loose clothing should not be worn.

13. Residual chemicals may reside on objects and be carried into your mouth causing corrosive and/or toxic reactions.

14. Splash goggles are required - they protect the eyes. Contact lenses are prohibited and can fuse to the eye upon chemical exposure and/or may prevent treatment to eye in cause of an emergency.

Extensions and Variations:

Demonstrations are optional.

References:

Block, Lori; Central Michigan University, Safety Violations Picture, 1997.

Flinn Scientific: "Acid in the Eye" Demonstration; Illinois, 1997.

Gorman, Christine E.; "Working Safely with Chemicals in the Laboratory, 2nd Edition"; Genium Publishing Corporation: New York, 1996, pp 20-45.

"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals"; National Academy of Sciences, National Academy Press: Washington D.C., 1995.

Stock, Laurence; Central Michigan University, Hazard Labels, 1997.

Teaching Environmental Health and Safety in a Chemical Technology Program; PACT workshop; Delta College: University Center, 1997.