Republic of the Philippines
Department of Education

DepED

Tanggapan ng Kalihim
Office of the Secretary

NOV 30 2006

DepED Order
No. 48, s. 2006

OBSERVANCE OF SAFETY MEASURES IN SCIENCE LABORATORIES

To: Regional Directors
Schools Division/City Superintendents
Heads, Public and Private Elementary and
Secondary Schools

1. In order to ensure safety in science laboratories, schools are directed to implement strictly the guidelines provided in the Laboratory Manuals (attached herewith) issued by this Department on the management of hazards and observance of safety measures in the performance of laboratory activities and handling of tools and equipment and chemicals.

2. The guidelines, as reiterated in this Order, cover the following:

   a. Science Laboratory Standards
   b. Design of science laboratory
   c. Laboratory management and safety
   d. Laboratory safety rules
   e. List of dangerous chemicals
   f. Handling/hazards of some chemicals
   g. Chemical storage
   h. Disposal of chemicals
   i. National Fire Protection Association (NFPA) recommendations for labeling of chemicals
   j. Using/Cleaning glassware
   k. First Aid Kit

3. Science teachers should ensure that students are informed of the hazards and are trained in the safe handling and use of equipment and chemicals.

4. School heads should implement stringent security and safety measures in the use of science laboratories. A full-time laboratory technician or a science teacher should be assigned to take charge of the science laboratories.

5. School heads should promptly report all accidents whether or not they result in an injury and ensure immediate and proper treatment, if needed. It is also required that the proper authorities such as the Department of Environment and Natural Resources, Department of Science and Technology, Department of Health, or the appropriate agency are informed at once for the expert management of the emergency situation.

6. Strict adherence to the guidelines is expected.

JESLI A. LAPUS
Secretary

Encl.: As stated
Reference: N o n e
Allotment: 1—(D.O. 50-97)
To be indicated in the Perpetual Index
under the following subjects:

EQUIPMENT
SAFETY EDUCATION
SCIENCE EDUCATION
RULES & REGULATIONS

(Enclosure to DepED Order No. 48, s. 2006)

DEPARTMENT OF EDUCATION | REPUBLIC OF THE PHILIPPINES

SAFETY MANUAL FOR SCIENCE LABORATORIES IN SECONDARY SCHOOLS

2006

SAFETY MANUAL

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SAFETY MANUAL

Laboratory Safety Guidelines— 40 Steps to a Safer Laboratory

The Laboratory Safety Institute is an international educational organization for health, safety, and environmental affairs

Their motto is *Teach, Learn, and Practice Science Safely.* Teaching, Learning, and Practicing Science Safely means that before you do an experiment, demonstration, or activity—

- **YOU KNOW** the hazards.
- **YOU KNOW** the worst things that could happen.
- **YOU KNOW** what to do and how to do it if they should happen.
- **YOU KNOW** and use the prudent practices, protective facilities, and protective equipment needed to minimize the risks.

The Laboratory Safety Institute offers these suggestions for improving laboratory safety. Having an understanding of inherent hazards and learning how to be safe should be an integral and important part of science education, work, and life.

Steps Requiring Minimal Expense

1. Have a written health, safety and environmental affairs (HS&E) policy statement.

2. Organize a departmental HS&E committee of employees, management, faculty, staff and students which will meet regularly to discuss HS&E issues.

3. Develop an HS&E orientation for all new employees and students.

4. Encourage employees and students to care about their health and safety and that of others.

5. Involve every employee and student in some aspect of the safety program and give each specific responsibilities.

6. Provide incentives to employees and students for safety performance.

7. Require all employees to read the appropriate safety manual. Require students to read the institutions laboratory safety rules. Have both groups sign a statement that they have done so, understand the contents, and agree to follow the procedures and practices. Keep these statements on file in the department office.

8. Conduct periodic, unannounced laboratory inspections to identify and correct hazardous conditions and unsafe practices. Involve students and employees in simulated OSHA inspections.

9. Make learning how to be safe an integral and important part of science education, your work, and your life.

10. Schedule regular departmental safety meetings for all students and employees to discuss the results of inspections and aspects of laboratory safety.

11. Require every prelab/pre-experiment discussion to include consideration of the health and safety aspects.

12. Forbid working alone in any laboratory and working without prior knowledge of a staff member.

13. Don't allow experiments to run unattended unless they are failsafe.

14. When conducting experiments with hazards or potential hazards, ask yourself these questions—

    - What are the hazards?
    - What are the worst possible things that could go wrong?
    - How will I deal with them?
    - What are the prudent practices, protective facilities and equipment necessary to minimize the risk of exposure to the hazards?

15. Require that all accidents (incidents) be reported, evaluated by the departmental safety committee, and discussed at departmental safety meetings.

16. Extend the safety program beyond the laboratory to the automobile and the home.

17. Allow only minimum amounts of flammable liquids in each laboratory.

18. Forbid smoking, eating and drinking in the laboratory.

19. Do no allow food to be stored in chemical refrigerators.

20. Develop plans and conduct drills for dealing with emergencies such as fire, explosion, poisoning, chemical spill or vapor release, electric shock, bleeding and personal contamination.

21. Display the phone numbers of the fire department, police department, and local ambulance either on or immediately next to every phone.

22. Store acids and bases separately. Store fuels and oxidizers separately.

23 Maintain a chemical inventory to avoid purchasing unnecessary quantities of chemicals.

24. Use warning signs to designate particular hazards.

25. Require good housekeeping practices in all work areas.

26. Develop specific work practices for individual experiments, such as those that should be conducted only in a ventilated hood or involve particularly hazardous chemicals. When possible most hazardous experiments should be done in a hood.

Steps Requiring Moderate Expense

27. Allocate a portion of the departmental budget to safety.

28. Require the use of appropriate eye protection at all times—in a laboratories and areas where chemicals are transported.

29. Provide adequate supplies of personal protective equipment—safety glasses, goggles, face shields, gloves, lab coats, and bench top shields.

30. Provide fire extinguishers, safety showers, eyewash fountains first aid kits, fire blankets and fume hoods in each laboratory and test or check monthly.

31. Maintain a centrally located departmental safety library—

- *Safety in Academic Chemistry Laboratories*, American Chemical Society, 1155 16th St., NW, Washington, DC 20036
- *Fire Protection Guide on Hazardous Materials,* National Fire Protection Association, Batterymarch Park, Quincy, MA 02269
- *Manual of Safety and Health Hazards in the School Science Laboratory*
- *Safety in the School Science Laboratory*
- *School Science Laboratories: A guide to Some Hazardous Substances*, Council of State Science Supervisors, Route 2, Box 637, Lancaster VA 22503
- *Handbook of Laboratory Safety*, 4th edition, CRC Press, 2000 Corporate Boulevard NW, Boca Raton, FL 33431
- *Prudent Practices in the Laboratory: Handling and Disposal of Hazardous Chemicals*, 2nd Edition, *1995*
- *Biosafety in the Laboratory*, National Academy Press, 2101 Constitution Avenue NW, Washington, DC 20418
- *Safety in School Science Labs*, Clair Wood, 1994, Kaufman & Associates, 192 Worcester Road, Natick MA 01760
- *The Laboratory Safety Pocket Guide*, 1996, Genium Publisher, 1 Genium Plaza, Schnectady, NY
- *Learning By Accident*, volume 1, 1997, The Laboratory Safety Workshop, Natick, MA 01760

  All of these books are available from *The Laboratory Safety Workshop*

32. Provide guards on all vacuum pumps and secure all compressed gas cylinders.

33. Provide an appropriate supply of first aid equipment and instruction on its proper use

34. Remove all electrical connections from inside chemical refrigerators and require magnetic closures.

35. Require grounded plugs on all electrical equipment and install ground fault interrupters (GFIs) where appropriate.

36. Label all chemicals to show the name of the material the nature and degree of hazard, the appropriate precautions, and the name of the person responsible for the container.

37. Develop a program for dating stored chemicals and for re-certifying or discarding them after predetermined maximum periods of storage.

38. Develop a system for the legal, safe and ecologically acceptable disposal of chemical wastes.

39. Provide fireproof cabinets for storage of flammable chemicals.

40. Provide secure, adequately spaced, well-ventilated storage of chemicals.

The Laboratory Safety Institute

The Laboratory Safety Guidelines are available as a 2 'x 3' poster and in an expanded version which discusses each of the 40 suggestions.

Laboratory Tools and Techniques

SCIENCE AND TECHNOLOGY III TEACHERS GUIDE

LABORATORY MANAGEMENT AND SAFETY

Managing a chemistry laboratory requires the teacher to develop a system suited to school conditions, administrative policies, class size, etc. The system must incorporate safety rules to be followed by students in the laboratory. It must also include procurement procedures and assignment of tasks and responsibilities.

Chemistry teachers are expected to have knowledge of the safety, hazards, and required storage conditions for equipment and chemicals. They are also expected to cope with chemical disposal problems met in the classroom.

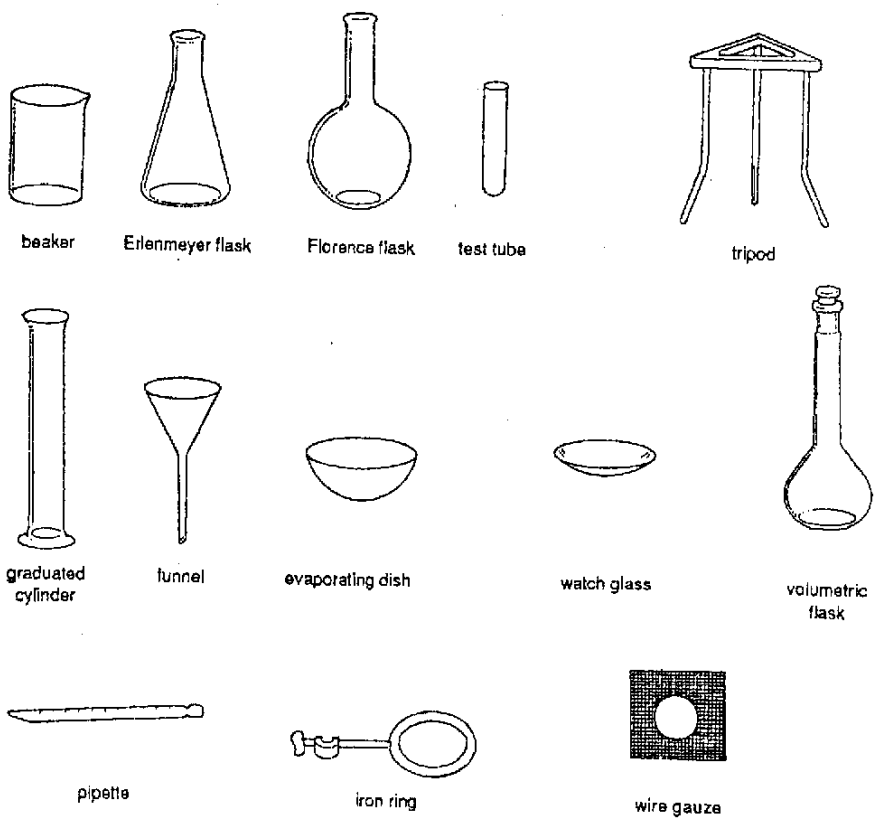


Fig. 1. Common laboratory glassware and tools

I. HANDLING/HAZARDS OF SOME CHEMICALS

Common chemicals in daily use in a chemistry laboratory may pose certain hazards to users. Users must be aware of the particular hazards posed by these chemicals and be knowledgeable of their proper handling procedures.

1. Acetic Acid (CHC_3H)

   Properties: Watery liquid, colorless, strong vinegar odor
   Hazard: Corrosive, particularly when diluted
   Avoid contact with liquid and vapor.

2. Ammonium Chloride (NH_4Cl)

   Properties: Solid, white, odorless
   Hazards: Not flammable; Toxic and irritating ammonia and hydrogen chloride gas may form in fire

3. Ammonium Hydroxide Solution (NH_4OH)

   Properties: Colorless liquid, very pungent odor
   Hazard: Fumes are formed when brought near volatile acids

4. Benedict Solution

   Description: Mixture of 18 g copper sulfate and 100 g anhydrous sodium carbonate, 200 g potassium citrate, 125 g potassium thiocyanate and 0.25 g potassium ferrocyanide per liter.

5. Benzoic Acid (C_6H_5COOH)

   Properties: Solid crystals or powder, white, faint pleasant odor
   Hazard: Combustible, dust may form explosive mixture with air
   Dust: Irritating to nose and throat if inhaled
   Solid: Irritating to eyes and skin
   Avoid contact with solid and dust.

6. Boric Acid (H_3BO_3)

   Properties: Solid, white, odorless
   Hazard: Not flammable, irritating to eyes and skin.
   Wear protective goggles and gloves.

7. Calcium Carbide (CaC_2)

Properties: Solid granules, gray to bluish black, garlic odor
Hazard: flammable; explosive gas is produced on contact with water (dangerous when wet); Stable in absence of moisture.

8. Calcium Chloride ($CaCl_2$)

Properties: Solid or water solution, odorless
Hazard: Not flammable; avoid contact with solution or solid; will burn skin and eyes.
Wear protective goggles, rubber gloves.

9. Calcium Oxide (CaO)

Properties: Solid granules, odorless
Hazard: Not flammable; but may cause fire on contact with water and combustibles. Will burn skin and eyes.
Wear protective gloves and goggles.

10.Carbon Tetrachloride (CCl_4)

Properties: Watery liquid, colorless sweet odor
Hazard: Not flammable; poisonous and irritating gases are products when heated, suspected carcinogen

11.Copper sulfate ($CuSO_4$)

Properties: Solid granules or crystals; white to blue; odorless

12.Ethanol or Ethyl Alcohol (C_2H_5OH)

Properties: Watery liquid, colorless, alcohol odor
Hazard: Flammable; irritating vapor is produced.
Wear protective goggles and gloves.

13.Iron (III) Chloride or Ferric Chloride ($FoCl_3$)

Properties: Solid, greenish black, odorless
Hazard: Not flammable; avoid contact with solid and dust.
Wear protective goggles, gloves and apron.

14.Hydrochloric Acid (HCl)

Properties: Watery liquid, colorless, sharp, irritating odor
Hazard: Not flammable; but flammable gas may be produced on contact with metals.
Vapor: Irritating to eyes, nose and throat
Liquid: Will burn skin and eyes

15.Hydrogen Peroxide (H_2O_2)

Properties: Water liquid, colorless, slightly sharp color
Hazard: May cause fire and explode in contact with combustibles and metals; containers may explode when heated.
Vapor: Irritating to eyes, nose and throat.
Wear protective garments.
Grades of purity: Common commercial strengths are 27.5%, 35%, 50% 70%, 90% and 98%. "High Strength" means greater than 52%. The hazard increases with the strength.
Stability during transport: Pure grades are quite stable, but contamination with metals or dirt can cause rapid or violent decomposition.

16.Iodine (I_2)

Properties: Bluish-black scales or plates, metallic luster
Hazard: Attack metals in presence of moisture and slowly acts on organic tissue. Keep bottle tightly closed.

17.Lead Nitrate ($Pb(NO_3)_2$)

Properties: Solid, white, odorless
Hazard: Cases may be produced when heated; not flammable; one of the toxic heavy metals.
Dust: Poisonous if inhaled (will cause dizziness or unconsciousness)
Solid: Irritating to skin and eyes
Wear dust mask and protective gloves.

18.Manganese Dioxide (MnO_2)

Caution: Strong oxidizer hence it should not be heated or rubbed with organic matter or other oxidizable substances, e.g., sulfur, etc.

19.Naphthalene ($C_{10}H_8$)

Properties: Solid, colorless, mothball odor
Hazard: Combustible, irritating to skin and eyes

20.Nitric Acid (HNO_3)

Properties: Watery liquid, colorless to light brown, choking odor
Hazard: Not flammable; may cause fire on contact with combustibles; flammable gas may be formed on contact with metals
Vapor: Will burn eyes, nose and throat
Liquid: Will burn skin and eyes
Grades of purity: various grades: 52-98%
Stability during transport: When heated may give off toxic red oxides of nitrogen.

21.Phenol (C_6H_5OH)

Properties: White solid or light pink liquid
Caution: Avoid contact with liquid and solid; combustible, poisonous gases are product in fire.

22.Phenolphthalein ($C_{20}H_{14}O_4$)

Properties: White or yellowish crystals, almost insoluble in water

23. Potassium Bromide (KBr)

Properties: Colorless crystals or white granules or powder
Hazard: Prolonged intake may cause mental deterioration, acne form skin eruption.

24.Potassium Chloride (KCl)

Properties: White crystals or crystalline powder
Hazard: Large doses by mouth can cause purging, also weakness and circulatory disturbances

25.Potassium Chromate (K_2CrO_4)

Properties: Solid, bright yellow, odorless
Hazard: Not flammable, may cause fire on contact with combustibles.

Dust: Irritating to eyes, nose, and throat
Solid: Poisonous if swallowed, irritating to skin and eyes

26.Potassium Dichromate ($K_2CR_2O_7$)

Properties: Solid crystals, red to orange, odorless
Hazard: Not flammable, may cause fire on contact with combustibles, cool exposed container with water.
Dust: Irritating to eyes, nose and throat
Solid: Will burn skin and eyes
Wear protective dust mask, gloves, goggles or face shields.

27.Potassium Iodide (KI)

Properties: Solid crystals, odorless
Hazard: Not flammable, harmful if swallowed.
Wear goggles or face shield.

28.Potassium Nitrate or Salt Peter (KNO_3)

Properties: Colorless transparent prism, white granular or crystalline powder, cooling saline
Hazard: ingestion of large quantities; may cause violent gastroenteritis; prolonged exposure may produce anemia, methemoglobinemia, nephritis

29.Sodium Hydroxide (NaOH)

Properties: Solid flakes or pellets, white, odorless
Hazard: Not flammable, may cause fire on contact with combustibles, cool exposed containers with water.
Dust: Irritating to eyes, nose and throat
Solid: Will burn skin and eyes
Wear safety goggles, dust mask.

30.Sodium Sulfate or Salt Cake (Na_2SO_4)

Properties: Powder or orthorhombic bipyramidal crystals

31.Sulfur (S)

- (Sublimed and washed sulfur are in the form of a fine, yellow crystalline powder, with only a faint odor and taste.)
- Provide good ventilation; isolate from chlorates, nitrates and other oxidizing materials.

- In contact with organic materials causes violent combustion on ignition. Store in dry place, prevent contact with organic material.

32.Sulfuric Acid (H_2SO_4)

Properties: Oily liquid, colorless, odorless
Hazard: Not flammable; may cause fire on contact with combustibles; flammable gases may be produced on contact with metals. Isolate from salt peter, metallic powders, carbides.
Mist: Irritating to eyes, nose and throat
Liquid: Will burn skin and eyes
Wear safety goggles, gloves, apron/suit.
Extremely hazardous in contact with many materials particularly metals and combustibles. Dilute acid reacts with most metals releasing hydrogen which can form explosive mixtures with air.
Grades of Purity: CE, LISP. Technical at 33% to 98%
Venting: Open

33.Zinc Nitrate ($Zn(NO_3)_2$)

Properties: Solid, white, odorless
Hazard: Not flammable, may increase the intensity of fire.
Dust: Irritating to eyes, nose and throat
Solid: Irritating to skin and eyes
Wear dust mask, goggles and gloves.

II. LABORATORY SAFETY RULES

Accidents in a science laboratory can be minimized, if not completely avoided, when students consciously observe safety rules.

a. Eye Protection: All students must wear safety goggles or Industrial quality safety spectacles in laboratories, where chemical work is done.

b. Warning Signs: "No smoking", "Caution-Radiation *Area"* or other warning signs must be strictly obeyed.

c. Horseplay: Horseplay and practical joking of any kind is strictly forbidden.

d. Labelling Cylinders: AU containers of chemicals must be clearly labelled showing the name of the chemical, date, owner's name, and safety precaution if hazardous.

e. Securing Compressed Gas Cylinders: Compressed gas cylinders must be secured with a strap or chain at all times.

f. Working Alone: No one should perform experimental work in a chemical laboratory unless a second person is present or located within calling distance.

g. Work Authorization: Unauthorized experiments are forbidden. Before any experiment is performed in an instructional laboratory, approval must be given by the instructor in-charge. Experimental work in research laboratories must be a part of the program approved by the research director.

h. Radiation Hazards: Experimental work with radioactive materials or equipment generating ionizing radiation is strictly forbidden.

i. Reporting Accidents and Fires: All accidents resulting in injury, property damage, or fire must be reported promptly to the appropriate authority.

Safety Habits

Several habits related to laying the foundation for a safe laboratory become obvious through working with the uninitiated student. These include the following:

a. Wearing safety glasses, aprons, and protective sleeves should become habitual to students working in the chemical laboratory.

b. Careful reading of reagent bottle labels. There is a great difference indeed between potassium chloride and potassium chlorate; between mercurous chloride and mercuric chloride; between manganese and magnesium.

c. Long sleeves should be rolled above the wrists as a definite safety habit.

d. Talking is permitted if control and restraint are practiced.

e. Studying the PURPOSE of an experiment becomes one of the most important steps of beginning chemistry laboratory practice.

f. It should be emphasized that test tubes or any pieces of equipment which have a potential for expelling a gas or liquid should be pointed away from the group partner or fellow worker.

g. Students should instinctively check all glassware for cracks prior to use.

h. Glassware of all types should be placed at the back of the laboratory bench to prevent falling and unnecessary breakage.

i. When it becomes necessary to carry long pieces of glass tubing, the student should be instructed to hold it vertically when walking through the laboratory.

j. ALL INJURIES, REGARDLESS OF HOW MINOR, SHOULD BE REPORTED TO THE INSTRUCTOR IMMEDIATELY.

k. In all cases of diluting acids THE ACID SHOULD ALWAYS BE ADDED TO THE WATER. The teaching of this phase of safety as a habit rather than a "diluting technique" becomes apparent to the experienced teacher.

l. The laboratory hood should be used whenever there is a question of toxicity of a by-product gas or when poisonous or, toxic gases are used as a part of an experiment e.g.. H_2S,HCN..

m. Drains should be thoroughly flushed after spilling out reagents.

n. Good housekeeping is imperative in the chemistry laboratory, and the use of a floor crock or plastic pail for broken glassware and other disposable items should be emphasized - in the case of alkali metal scrap a kerosene-filled bottle should be available, for storage or disposal of the material.

Lab Safety

When working in laboratories, there is always a risk that an experiment may go wrong. Most often, laboratory work exposes you to experiments invoking fire and chemicals that may become hazardous if handled without careful and proper preparation.

Be guided by these steps to ensure that learning in the laboratory will always be fun and safe.

Objectives

1. Know safe and proper behavior in laboratories.
2. Understand the potential danger in conducting experiments.
3. Prepare for emergency situations that may occur.

Life skill

Knowledge and ethics can make science work for us and not against us.

Plan your work

Before you conduct any experiment, ask yourself the following questions:

1. *What are the possible dangers of this experiment?*
2. *What are the potential hazards of the materials that I will be using (such as corrosive properties, chemical reactions, flammability and toxicity)?*
3. *What else can possibly go wrong?*
4. *Am I prepared to deal with the things that could go wrong?*
5. *What are the good practices, protective facilities and equipment I need in case of on emergency or to minimize exposure to the possible hazards?*

Always read specific information and orient yourself with each of the chemicals you are about to work on so you know what to expect.

Before conducting the experiment

Familiarize yourself with the rules and regulations when using the laboratory. Above all, orient yourself with the properties of the chemicals to be used, particularly their hazards. Once you know what experiments to perform and the chemicals involved, check equipment.

- Are you wearing the right attire? Chemically resistant gown/apron, gloves and goggles are designed for your protection and safety.

- Are you comfortable with what you're wearing. Clothes should not restrict movement. Shoes that are high-heeled, open-toed or made of woven materials may make you trip or fall during the experiment.

- Are you protected? Don't wear shorts or miniskirts. The idea here is to always keep every part of your body protected, including your legs.

- Is your field of vision OK? Your hair should not cover your face or block your sight. Above all, it shouldn't get in the way of actual experiments. Tie-up long hair and put loose clothing under lab gown.

- Have you inspected the work area? Make sure it is clean and free from any mess that may result to accidents. The floor should be free from obstruction. Keep doors and laboratory passageways clear.

- Have you checked electrical equipment and cords for tattered wiring and minor defects?

- Have you inspected the equipment or apparatus for any damages?

Emergency procedures

Every laboratory should have a First Aid kit. It helps also to know emergency procedures. Make sure you take note of the following:

- Location of the wash area.
- Exit points and procedures in case of on emergency.

In case of fire, call the attention of your classmates and instructor and leave the room. Don't endanger yourself by trying to save a piece of equipment or prevent damage to the building. Get out as fast as you can. The last person to leave should close the door to prevent fire and smoke from spreading.

While conducting the experiment

It is important to keep yourself safe in the laboratory. Strictly observe the following safety procedures:

- Always keep your eyes protected, especially if you need to observe an experiment at a close distance. Wear chemical goggles.

- Pour liquids carefully to prevent skin contact and spills. Quickly clean up any spills.

- Absolutely no eating inside the laboratory.

- As much as possible, wear gloves when handling chemicals. Remember: Latex gloves are not compatible with most chemicals, Nitrite gloves offer better protection. Ask your instructor about available gloves.

- Don't work alone. At least two people must be present.

- The laboratory must have adequate ventilation and air circulation.

- Never use a mouth suction to fill a pipette. Use a pipette bulb or other pipette-filling devices.

- Don't just throw away chemicals down the drain. Ask your instructor about proper chemical disposal and apparatus cleaning procedures.

- Report any accident, no matter how small, to your instructor.

- Keep a safe distance from other students who are conducting an experiment. Pay attention to how your classmates handle materials and equipment because someone else's mistake can hurt you.

- The laboratory is not a playground so don't engage in horseplay, pranks or other acts of mischief. While experiments are fun and highly interesting, they should be taken seriously. Always act responsibly.

Special Safety Duty: Implications for the Chemistry Teacher

The chemistry teacher will fulfill his accident prevention responsibilities if he conducts the same type of safety program expected of every supervisor in industry. The following are some guidelines:

1. Have a thorough understanding of the potential hazards of all the materials, processes, and equipment that will be in the school laboratory.

2. Fully instruct every pupil in the necessary laboratory safety requirements established as a condition of participation. Check student's understanding of these requirements with carefully-developed written test, signed by the pupil and kept on file; a near-perfect score should be required for participation in laboratory activities.

3. Supervise closely the daily activities of pupils in laboratories to be reasonably sure of good compliance with safety requirements. Take (and keep a record of) disciplinary action for any willful violation of safety rules. Reinstruct as necessary to ensure complete understanding.

4. Take prompt action to correct any unsafe conditions and practices. Inform the school administration in writing of any unsafe condition the teacher himself cannot correct; suspend related student activities until the condition has been corrected. No task should be deemed so important that it may be knowingly done unsafely.

After the experiment

- **Shut Down.** Turn off electrical switches and gas valves used for the experiment. Cover all containers properly.

- **Clean equipment.** Glassware and apparatus should be washed or cleaned immediately after use. Ask your instructor about proper cleaning, washing and rinsing procedures for specific glassware.

- **Store equipment.** Never leave used glassware on the tabletop. Store them in their proper places such as shelves or racks.

- **Use a tray.** It is advised that you use a tray to collect apparatus or glassware prior to cleaning. This practical tip reduces the risk of accidents resulting from direct handling.

- **Check labels.** All containers should be kept clean and clearly labeled to reduce chances of using the wrong equipment or substance.

- **Wipe the counter.** The laboratory tabletop should be wiped and decontaminated with soap and detergents.

- **Wash hands.** Always wash your hands after conducting experiments, especially before eating. The soap and detergent you use should be for hand washing. Don't use the same cleaning substances used for washing equipment because they may be contaminated with chemicals.

- **Ask permission.** Before you leave, inform your instructor so he or she can inspect the laboratory room.

III. CHEMICAL STORAGE

Chemical storage should take foremost priority. Some guidelines in storing chemicals are:

a. Chemicals should not be arranged in alphabetical order which is the most frequent method of storage. Incompatible materials may be brought close to one another by this method. Storing chemicals in alphabetical order is potentially dangerous and increases the possibility for unplanned, hazardous combination of chemicals. Many persist in this practice simply because they have not been made fully aware of all the implications and dangers. Besides it is the method we are accustomed to. Ease of retrieval should be made secondary to considerations of safety and security.

b. To lessen accident potential, preferably store chemicals in multiple locations within the building. When this is not possible, maximize the distance between classes of chemical compounds within the storage area.

c. In all cases, store acids and bases with the greatest multiple locations within the building. Separate storage rooms represent ideal situations.

d. Do not expose general storage areas to extreme heat or to direct sunlight. Either one may result in a rapid deterioration or possible decomposition of many compounds.

e. Recommended storage design of any chemical storage area is build around the utilization of six distinctly different compartments. (See Fig. 2.) Each area stores substances belonging to a specific class of chemicals. Within each area, designate separate shelves for families of compounds. This will use the space in a manner that puts maximum distance between incompatible substances. Each compartment serves a specific need.

   Members of compatible families are housed on the same shelf, e.g., oxides, carbonates, sulfides. Within any family, chemicals may be arranged alphabetically to facilitate easy retrieval.

f. Dry inorganic substances should be stored in compartment A. Avoid any possible contact of cyanides with acids which may cause generation of highly poisonous HCN. Cyanides should be stored above, not below acids. Cyanides should be inventoried only after a careful reevaluation of the need for them.

g. Storing oxidizing agents (chlorates, dichromates, hydrogen peroxides, and nitrate) poses special problems. These should be kept away from combustible materials, organic solvents, phosphorus, metal hydrides, and metal powders.

h. Inorganic acids except nitric acid should be stored together in area H (no more than 1 gallon quantities located on a lower shelf). They should not be housed on the floor where they could be accidentally kicked, resulting in spill.

i. Basic solutions should be housed in areas away from dry chemicals and on stockroom shelves near the floor. Inorganic hydroxides are best stored in polyethylene containers. As with acids, bottles are best placed on trays to contain the spread of liquid in the event of breakage. Because of their short shelf life, date of receipt should be recorded on the label.

j. Flammable chemicals should be maintained in an approved, vented cabinet that meets OSHA & NFPA standards. Where possible, this should be physically separated from other chemical materials and located away from potential sources of sparks or heat. Materials which are flammable should be stored in their original shipping containers or in containers specifically approved for their storage. Otherwise the quantity stored should be limited to 100g.

k. Nitric acid should be stored with the miscellaneous materials rather than the other acids. Nitric acid forms an explosive combination with acetic acid.

l. Alkali metals, if kept in inventory, should be maintained in glass stoppered containers using most restrictive measures. Na and K should be submerged in kerosene. Li is better stored in a container of mineral oil. As an added precaution, in the event of explosion, vessels containing Na and K must be embedded in an outer container of sand. User should be aware that K metal frequently forms a peroxide in the crust which when cut, oxidizes quickly traces of kerosene, creating the potential for explosion.

m. Sodium peroxide and calcium carbide should be stored in airtight containers that eliminate even the most remote possibility of contact with water. Penetration of even the smallest amount of water may produce violent reaction. The use of peroxides, in general, should be discouraged.

n. White (or yellow) phosphorus should be stored under water in a tightly stoppered glass container; this should then be placed in a metal container as an added precaution. When P is kept in inventory (which should be discouraged), it should be stored in a location that minimizes even the most remote chance of it being knocked off accidentally from the shelf.

o. Gas cylinders should be stored in the upright position, not on their sides, to minimize the chance of their nozzles being sheared off. They then become projectiles that can penetrate a brick wall. Large cylinders should be chained during both use and storage. They should be housed in a cool, dry place, away from potential sources of heat and sparks or flammables and corrosive materials. Empty cylinders should be labeled as such and stored away from full ones until removed.

p. Only 3% hydrogen peroxide should be kept in stock, not the 30% solution which becomes unstable after a period of time. The 3% hydrogen peroxide can be safely stored on the shelf along with other inorganic #9 chemicals. The 30% solution must be stored in an explosion proof refrigerator, if kept in the chemical inventory.

q. Ether must be purchased only in small quantities and unused portions must be disposed one month after opening its bottle. Ether, once opened, starts to form peroxide giving it a shelf life of but a few months. The friction resulting from as little as twisting the cap of an old can of ether has been known to cause an explosion, if peroxides have formed.

r. Chemicals which have been particularly identified as carcinogens should be totally excluded from the school stockroom. Others should be available only in very small quantities or when specific needs require their use.

s. Hazardous chemicals can be separated into four groups:

    1. Chemicals which should be absolutely prohibited from the science facility.

2. Chemicals which may be present only when a legitimate need justifies their inventory.
3. Chemicals which should be maintained in only restricted quantities, good only for one or two years use.
4. Chemicals which present very little hazard and may be stored in unrestricted quantities.

Proper chemical storage even though difficult must be faced squarely by teachers and critical issues resolved.

Approved method of chemical storage

AREA A - INORGANIC (DRY)

#1, Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide

#2, Halides, Sulfates Sulfites, Tbiosulfates, Phosphates

#3, Amides, Nitrates (not Ammonium Nitrate), Nitrites

#4, Metals & Hydrides, (Store away from any water)

#5, Hydroxides, Oxides, Silicates

#6, Arsenates, Cyanides (Store above acids)

#7, Sulfides, Selenides, Phosphides, Carbides, Nitrides

#8, Borates, Chromates, Manganates, Permanganates

#9, Chlorates, Perchlorates, Chlorites, Peroxides

AREA B - Inorganic Acids except Nitric Acid

AREA D - Bases

AREA C - ORGANIC

#1, Alcohols Glycols

#2, Hydrocarbons, Esters

#3, Ethers, Ketones

#4, Epoxy Compounds, Isocyanates

#5, Sulfides, Polysulfides

#6, Phenols, Cresols

#7, Peroxides, Azides

#8, Acids, Anhydrides, Peracids

AREA F Nitric Acid and Miscellaneous Items

AREA E (Flammable Cabinet) Flammables and Combustibles

Table 1. List of Dangerous Chemicals

Source: *Safety in the School Science. Laboratory*, U.S. Department of Health, Education, and Welfare

A. Examples of Incompatible Chemicals

Chemical	Keep Out of Contact With
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, glycol, perchloric acid, peroxides, permanganates
Alkaline metals, such as powdered aluminum or magnesium, sodium, potassium	Water, carbon tetrachloride or other chlorinated hydrocarbon, carbon dioxide, the halogens
Ammonia, anhydrous	Mercury (in manometers, for instance), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Carbon, activated	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic acid	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, the halogens
Hydrocarbons (butane, propane, benzene, gasoline, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide

Chemical	Keep Out of Contact With
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, combustible materials
Mercury	Acetylene, fulminic acid, ammonia
Nitric acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Potassium chlorate	Sulfuric and other acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium)
Ammonium nitrate	Acids, flammable liquids, metal powders, sulfur, chlorates, any finely divided organic or combustible substance
Bromine, chlorine	Ammonia, petroleum gases, hydrogen, sodium, benzene, finely divided metals
Iodine	Acetylene, ammonia, hydrogen
Hydrogen sulfide	Oxidizing gases, fuming nitric acid
Potassium permanganate	Sulfuric acid, glycerol, ethylene glycol
Sodium peroxide	Ethanol, methanol, glacial acetic acid, carbon disulfide, glycerol, ethylene, glycol, ethyl acetate

B. Explosion Hazards

Avoid the following combination among chemicals commonly found in the school science laboratory.

1. Na or IC with water
2. NH_4NO_3, Zn powder and a small amount of water
3. KNO_3 with CH_3COONa (sodium acetate)
4. Nitrate and an ester
5. Peroxides with magnesium, zinc or aluminum
6. Chlorate and sulfuric acid
7. Nitric acid with zinc, magnesium or other metals
8. Halogen and ammonia
9. Phosphorus with nitric add, a nitrate, or chlorate
10. Mercury (II) oxide with sulfur

C. Examples of hygroscopic and deliquescent substances

$AgNO_3H_2O$
(silver nitrate monohydrate)

$AlCl_36H_2O$
(aluminum chloride hexahydrate)

$Al(NO_3)_39H_2O$
(aluminum nitrate tetrahydrate)

$Bi(NO_3)_2)$
(bismuth nitrate tetrahydrate)

$CaCl_22H_2O$
(calcium chloride dehydrate)

$Co(NO_3)_26H_2O$
(cobalt nitrate hexahydrate)

$CrCl_3$
(chromium (III) chloride)

$Cu(NO_3)_23H_2O$
(copper (II) nitrate trihydrate)

$FeCl_36H_2O$
(iron III chloride hexahydrate)

$MgCl_2$ $6H_2O$
Magnesium chloride hexadrate)

Mg (NO_3) $6H_2O$
(magnesium nitrate hexahydrate)

$MgSO_4$
(magnesium sulfate)

$MnCl_2$ $4H_2O$
(manganese chloride tetrahydrate)

NaOH
(sodium hydroxide)

Na_2O
(Sodium oxide)

$NaC_2H_3O_2$ $3H_2O$
(sodium acetate trihydrate)

$ZnCl_2$
(zinc chloride)

C_6H_5OH
(phenol)

$Fe(NO_3)_3 9H_2O$
(iron (III) nitrate nonahydrate)

$Fe(CNS)_3\ 3H_2O$
(iron (III) thiocyanate trihydrate)

KOH
(potassium hydroxide)

$CH_3COO)_2O$
(acetic acid anydride)

D. Examples of volatile substances

$CH_3CH_2OCH_2CH_3$
(diethyl ether)

CS_2
(carbon disulfide)

CH_3COCH_3
(acetone)

$CHCL_3$
(chloroform)

CH_3CH_2OH
(ethanol)

CCl_4
(carbon tetrachloride)

$CH_3COOCH_2CH_3$
(ethyl acetate)

CH_3OH
(methanol)

E. Examples of chemical which burn or stain the skin

Concentrated acids

strong bases

phenol

$AsCl_3$
(arsenic (III) chloride)

$AgNO_3$
(silver nitrate)

PCl_3
(phosphorus (III) chloride)

liquid Br_2
(bromine)

$C_6H_5NH_2$
(aniline)

F. Examples of chemicals which are fire hazards

white and yellow P
phosphorus

CH_3CH_2OH
(ethanol)

$C_2H_5OC_2H_5$
(diethyl ether)

C_6H_6
(benzene)

CH_3COCH_3
(acetone)

IV. THE DISPOSAL OF CHEMICALS

Getting rid of chemicals is an integral part of the operation of managing a school laboratory. Some guidelines for chemical disposal are:

1. Check the shelves and stores at regular intervals for the presence of unlabelled containers or chemicals known to be dangerously unstable e.g., old samples of diethyl ether.

   Old samples of ether may be explosive because of formation of peroxides. Never attempt to distill these samples. Test for the presence of peroxides with a starch/iodide paper which will be discolored if peroxides are present. (Perform a blank)

2. Dispose of old stocks of potassium by adding small pieces ata time of the metal to t-butyl alcohol. Allow 100 mL of the alcohol to 2 g of K. Old stocks of K may also explode even when stored under mineral oil.

3. Get rid of excess stocks of flammables, known carcinogens, contaminated chemicals or products from practical work.

4. The small amounts of materials produced daily in school such as test tube and beaker quantities and washings from glassware of acids, alkalis, oxidizing and reducing agents and chemicals of relatively low toxicity may be allowed to be released into the drainage system with plenty of water under normal circumstances.

5. Small quantities of liquids or solutions can be rendered harmless by drawing them into a large bottle where they are diluted or neutralized by a large volume of a suitable liquid. In Figure 3, the

capillary tube restricts the flow of chemical into the large bottle and the screw clip is adjusted to ensure that the flow rate is sufficiently low to bring about effective dilution or neutralization. Larger quantities from stock bottle (up to 25dm^3), liter and kilogram quantities should be released in small quantities over a period of time (little and often technique).

6. Gases may be dissolved using either of the methods illustrated in Figure 4.

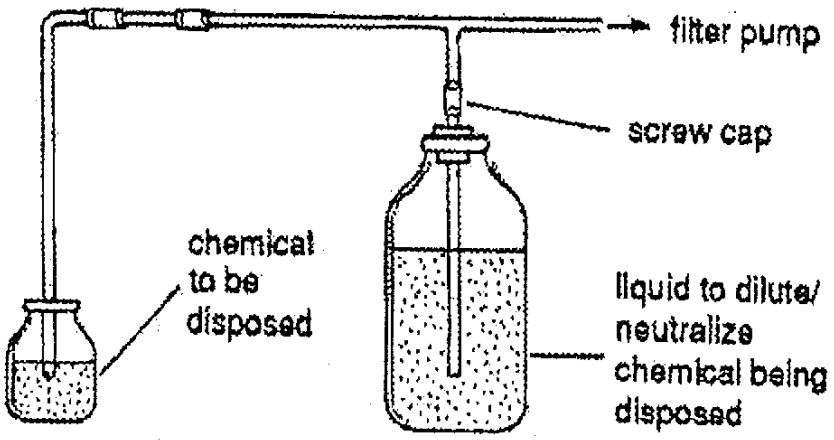


Figure 3. Disposal of harmful chemicals.

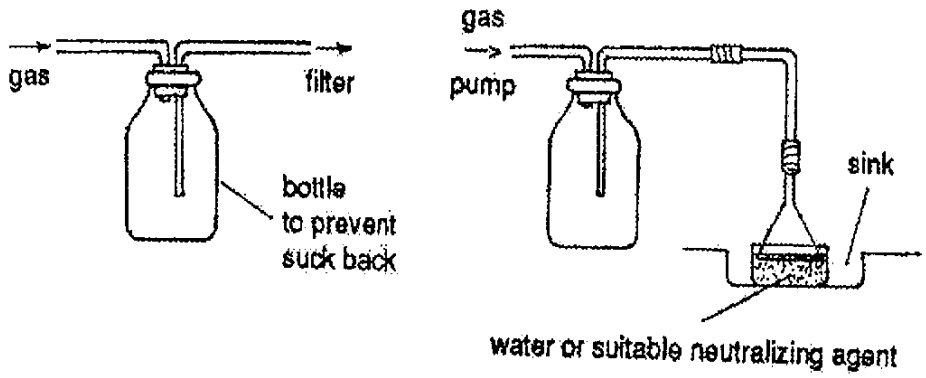


Figure 4. Disposal of Gases

7. Particularly toxic or harmful chemicals, less easily degraded materials such as halogenated alkanes or potentially explosive substances should be disposed of only by methods laid down by controlling authority. One possibility is to allow slow evaporation, if the solvent is left in a place not accessible to unauthorized persons, animals, etc.

8. Disposal by burial is not recommended nor is the burning of flammables unless this is allowed by the controlling authority.

9. A teacher is responsible not only to the student but also to the cleaners, refuse collectors, and others who may be involved in the subsequent handling of garbage and carelessly discarded waste, it is unacceptable to put materials out for disposal by people who are unaware of the hazards to cope with the consequential problems.

V. NTPA RECOMMENDATIONS FOR LABELING CHEMICALS

BLUE **Identification of Health Hazards** Types of Possible Injury	RED **Identification of Flammability** Susceptibility to Burning	YELLOW **Identification of Reactivity** Susceptibility to Release of Energy
Signal	Signal	Signal
4 Materials which on very short exposure could cause death or major residual injury even through prompt medical treatment was given	4 Materials which rapidly or completely vaporize at atmospheric pressure and normal ambient temperature and which will burn	4 Materials which are readily capable of detonation or of explosive decomposition or reaction at normal temperature and pressure.
3 Materials which on short exposure could cause serious temporary injury even though prompt medical treatment was given.	3 Liquids and solids that can be ignited under almost all ambient temperature conditions	3 Materials that are capable of detonation or explosive reaction but require a strong initiating source, or that must be heated under confinement, react explosively with water
2 Materials on which intense or continued exposure could cause serious temporary or residual injury even though prompt medical treatment was given	2 Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.	2 Materials that are normally unstable and readily undergo violent chemical changes but do not detonate; also materials that may react with water violently, or that may form potentially explosive mixtures with water.
1 Materials which on exposure could cause irritation but only minor residual injury even if no treatment is given	1 Materials that must be preheated before ignition can occur.	1 Materials that are normally stable, but that ca become unstable at elevated temperature and pressure, or that may react with water with some release of energy but not violently.

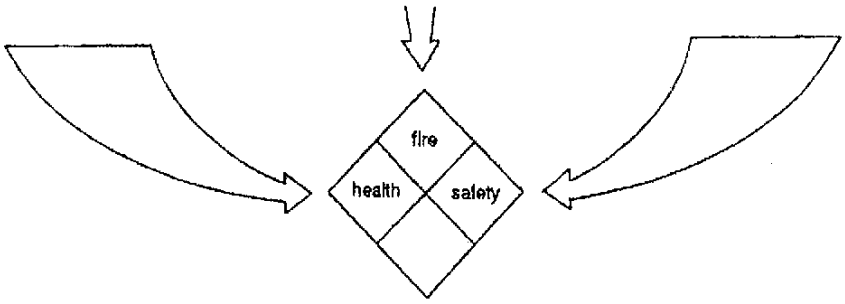
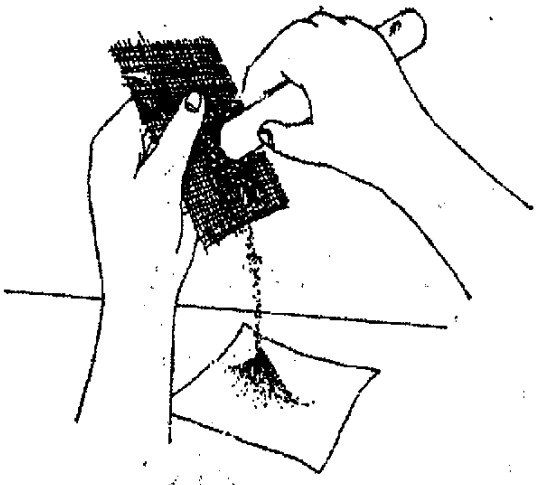


Figure 5. Examples of warning labels.

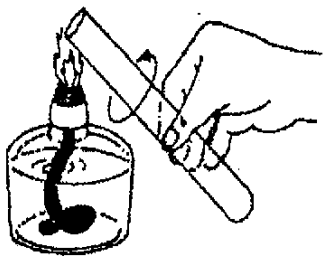
Using Glassware

Do not use cracked or chipped glassware.

a. Trim the sharp uneven edge of a broken cylinder or test tube by rubbing it with a piece of wire screen. Do this over a piece of paper.



b. When you have finished, fold the paper carefully then throw it in the waste can.
c. Fire polish the edges.



Be careful when handling hot glassware. Glass cools very slowly and hot glass looks the same as cool glass.

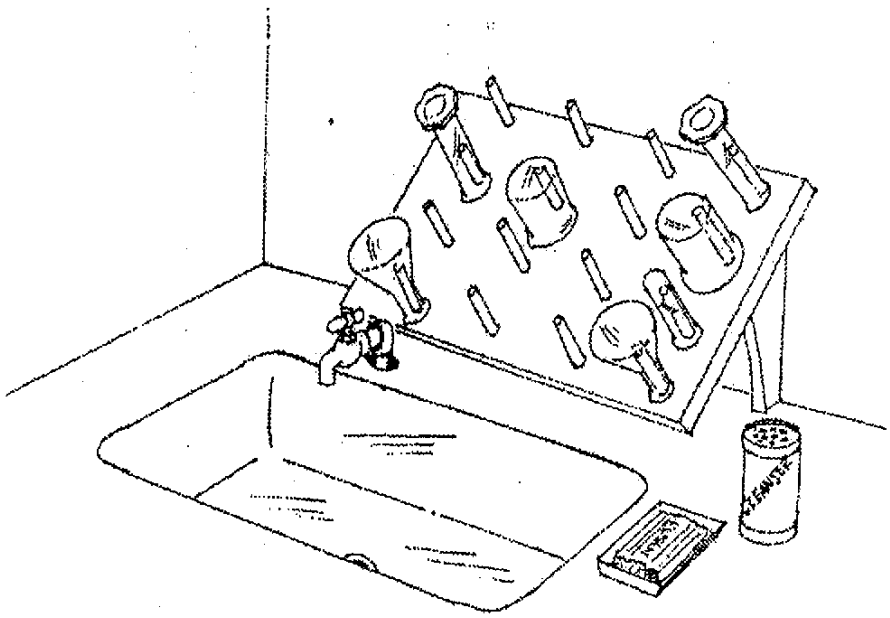
Cleaning Glassware

After every laboratory activity/experiment, clean all the glasswares used and store properly.

1. To clean glassware, use a little soap or detergent and an appropriate brush.
2. Rinse thoroughly with tap water.
3. If after the final rinse there is a continuous film of water adhering to the interior surface, the item is clean.
4. If, instead of the film, there are separate drops of water clinging to the surface, the item is still dirty and must be cleaned again.

Particulary stubborn cleaning problems will require special cleaning solutions such as commercial bleach. These are highly corrosive and should be used with care. Prompt cleaning of all glassware after use can avoid most problems.

Dry the glassware on a draining rack before keeping them in storage cabinets. Place this rack near the sink.



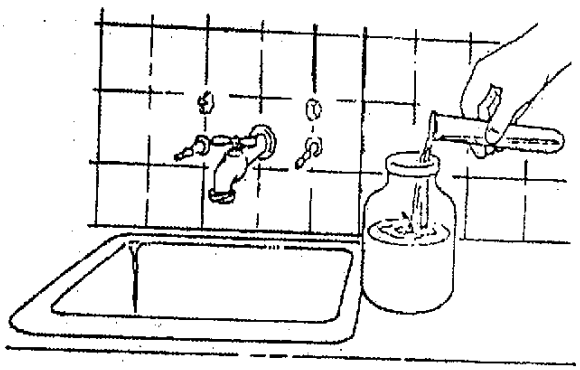
draining rack

First Aid Kit

Recommended minimum contents of first aid kit

1. Bandages/gauze for dressing
2. Absorbent cotton
3. Adhesive plasters
4. Safety pins
5. Blunt-nosed scissors
6. Antipyretic/analgesic tablets
7. Rubbing alcohol
8. Merthiolate
9. Ointment for minor skin burns
10. Forceps

- Appropriate safety equipment must be used whenever experiments are being conducted.
- A review on potential hazards associated with the experiment is necessary so that precautions can be taken to counteract or eliminate the hazards before beginning an experiment.
- Appropriate warning signs must be posted near any dangerous equipment, reaction or condition.
- Unauthorized experiments should not be allowed. Working alone in the laboratory must not be permitted.
- Appropriate waste disposal receptacles for solvents, glass, rags, paper, etc. may be provided.



DepEd Steps and Orders to Minimize Occurrence of Science Laboratory Accidents

1. Issue a DepEd Order/Memorandum on the following:

   a. In designing/constructing a Science Lab, the building must have the following features:

      a.1 The science laboratory should have a wide space to allow mobility inside the room.

      a.2 The room should have a bilateral fenestration for ventilation and fume extraction.

      a.3 There should be at least two (2) entry/exit doors for easy access and egress. The doors should be swing out to facilitate exit of students in case of emergency.

      a.4 The science laboratory should have provisions for laboratory counter, control mom and storage room.

      a.5 The laboratory/working tables inside the science Laboratory should be fixed on the floor. It should be made of reinforced concrete with mosaic tiles topping. Each working table should be provided with laboratory sink and faucet.

      a.6 The storage room and control room should be equipped with built-in cabinets not higher than 1.90 meters.

      a.7 Every science laboratory should be provided with First Aid Kit.

      See enclosed Standard Typical Layout Plan for Science Laboratories.

b. Guide/Steps to ensure that learning in the laboratory will always be safe (reiteration). ***To wit:***

b.1 Plan your work.

b.2 Before conducting the experiment, familiarize students with the rules and regulations when using the laboratory.

b.3 Orient the students with the properties of the chemicals to be used, particularly their hazards. Once you know what experiments to perform and the chemicals Involved, check equipment.

b.4 Know emergency procedures and the location of the first aid kit, wash area and exit points.

b.5 Good housekeeping is important when it comes to laboratory safety. Making sure that you clean as you go will help reduce accidents.

Source: 'Lab Safety Tips" from School Safety Reference Manual distributed in some schools nationwide as endorsed by former DepEd Secretary Edilberto De Jesus and former DepEd OIC Secretary Fe Hidalgo

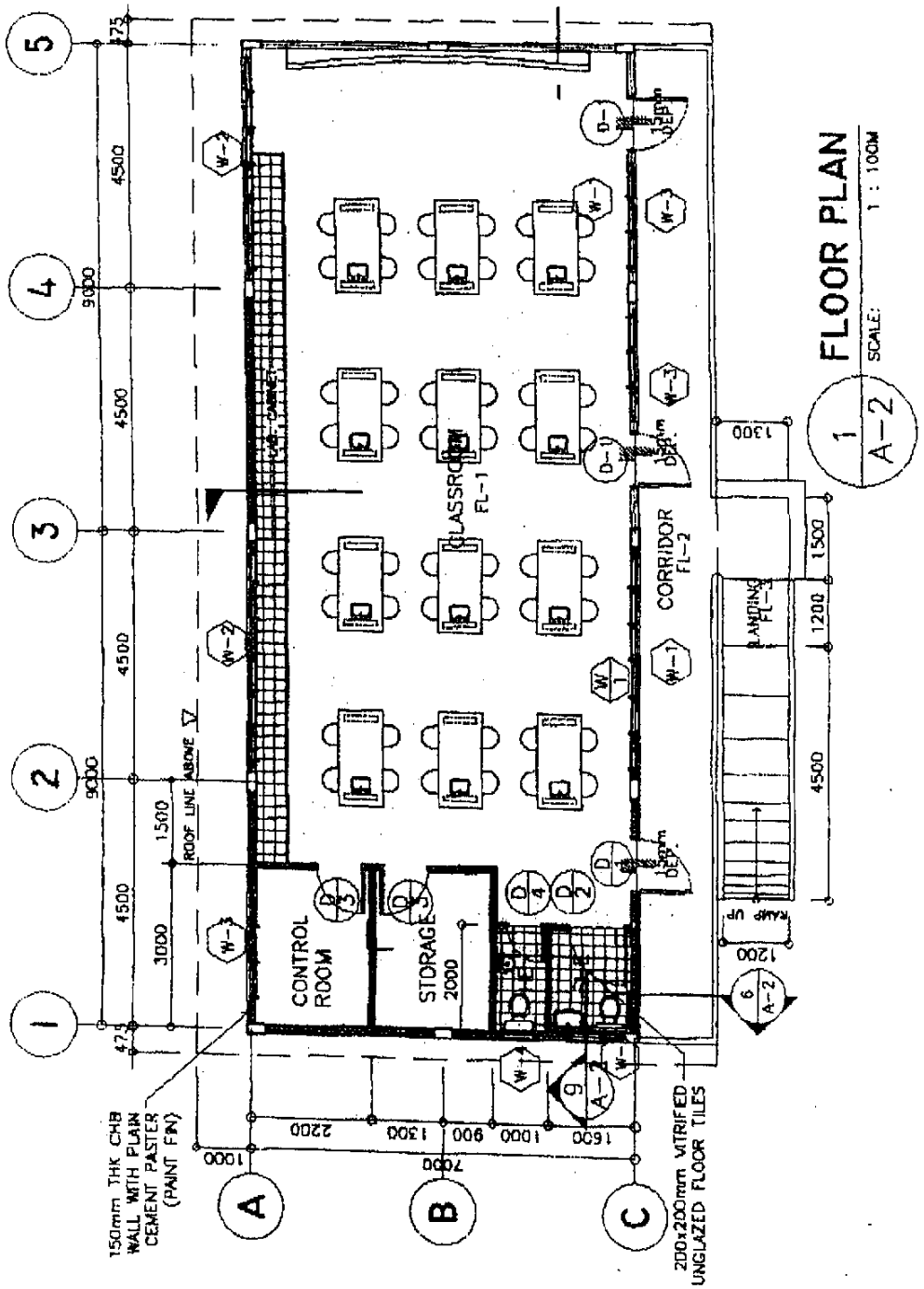


Fig. 2. Typical Layout Plan of Science Laboratory Room

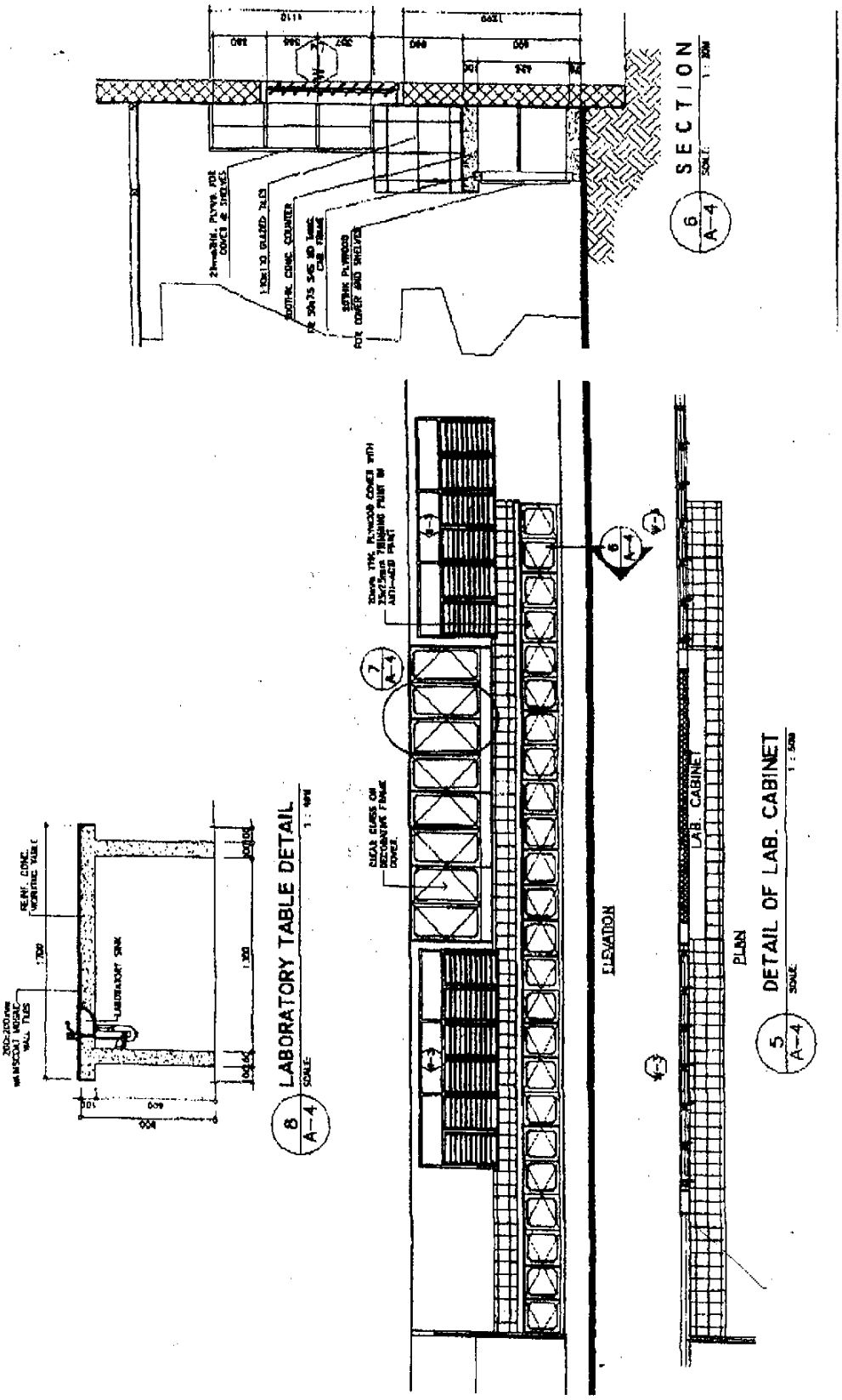


Fig. 3. Detail of Laboratory Table & Counter of a Science Laboratory Room