Safety in the High School Science Classroom

Pinellas County Schools
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Investigating Safely –
A High School Science Safety Guide

TEACHERS SHOULD

- carry out the basic laboratory safety programs as part of the curriculum
- instruct the students in laboratory safety and encourage a positive attitude toward laboratory safety awareness
- inform students of the purpose, procedures, and hazards of each experiment
- establish a set of laboratory safety rules that students are to follow during laboratory experiments
- make parents award of the laboratory safety program, its importance, and the student's responsibilities in the program
- verify that the physical facilities meet all safety requirements and report deficiencies in writing to the appropriate building administrator
- know the location and operation of all the safety equipment in the room

STUDENTS SHOULD

- follow the procedures for each laboratory activity
- wear suitable clothing and use personal protective devices
- know and follow the laboratory safety rules
- know the location of room exits and building evacuation routes
- know the location and operation of all the safety equipment in the room
- clean up the work area after each experiment
- notify the teacher of any possible hazards
- notify the teacher of any medical or physical limitations and use of contact lenses
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PARENTS SHOULD

- encourage responsibility and safety awareness in everyday life
- become aware of the laboratory safety program and encourage a positive attitude toward the program
- notify the school of any limiting conditions that could affect student performance in the laboratory

General Laboratory Techniques

The successful outcome of a laboratory experience for students is often predicated on a basic understanding of those techniques that will insure a safe learning experience.

GLASSWARE

Kinds of glassware

There are two kinds of glassware available for purchase from laboratory supply houses. The correct selection of soft or safety hardened glassware is important not only as a means of preventing student injury but also for the success of the experiment. To quickly categorize the ways common laboratory equipment items are marketed, consult the following:

Soft (Flint)

- glass tubing *
- graduated cylinder *
- test tubes *
- funnel *
- watch glass *
- volumetric glass
- pipet
- gas collecting bottle
- wide-mouth bottle

Heat-Tempered (Pyrex, Kimax) Hardened (Borosilicate)

- glass tubing *
- graduated cylinder *
- test tubes *
- funnel *
- watch glass *
- Florence flask
- Erlenmeyer flask

* The first 5 items on each list can be purchased in either quality of glass. The hardened or heat-tempered glass is usually more expensive.

Selecting the right glassware for each use

Soft glass tubing is used in procedures that require the bending of the glass in order to assemble apparatus. An example is a gas delivery tube.

Any other process that requires that chemicals or solutions be heated dictates the use of heat-tempered or borosilicate glassware. The safety problem lies in the imperfections in soft glass, around which hot spots can develop. These hot spots can cause the shattering of the glass and subsequent injury.

A common misuse of glassware is found in the preparation of solutions. Since the final volume of a standard solution of an acid, base, or salt is usually determined using a volumetric flask, many texts and laboratory manuals recommend that the solute and water solvent be mixed in a volumetric flask. The narrow chimney of the volumetric flask does not permit the heat generated in toe ionization of the acid to escape at a fast enough rte and the soft glass of the volumetric flask or graduated cylinder will often rupture, sending glass particles and acid solution in all directions. The same result may occur and can cause serious injuries when other strong acid and base solutions are prepared/ When diluting a strong acid or strong base or when preparing laboratory solutions of substances with a known exothermic heat of solution, the experimenter must use a heat-tempered graduated cylinder instead of a volumetric flask. In preparing a strong base from a solid, use a heat tempered beaker.

Inserting the glass tubing or thermometer into a holed stopper or rubber tubing

Several cautions must be considered when glass tubing is worked into the holes in stoppers if injuries are to be avoided. The procedures should also be followed for thermometers.

- Split the stopper if an airtight fit is not needed.
- Never attempt to force tubing through a hole that is to small for the tubing
- First lubricate both the hole and the end of the tubing with glycerine or water.
- Wrap the tubing and the stopper in layers of cloth or paper towel to protect the hands if the glass shatters in spite of precautions.
- Hold the stopper in one hand and hold the tube near the end that is to go in the stopper in the other hand. Keep hands close together.
- Slowly and gently work the tube into the stopper with a twisting motion. Do not hurry.

Removing glass tubing or thermometer

- Remove tubing as soon as possible to avoid "freezing" the tubing in the stopper.
- If freezing occurs, soak tubing and stopper overnight in soapy water before attempting to remove tubing.
- If the tubing is solidly frozen, discard the entire assembly or cut away the stopper. The risk involved in trying to free the tubing is more than the value of the tubing.

HEATING EQUIPMENT

Alcohol Burners

The use of alcohol burners is strongly discouraged, However, if they are used, the following points should be considered:

- Add a small amount of sodium chloride (table salt) to the alcohol. This will give a visible orange color to the flame.
- Never permit students to fill burners. The fuel bulk container should not be accessible to students.
- Fill burners only when they are cool.
- Do not substitute duplicator fluid or other flammable liquids for alcohol used for fuel. The substitute may have potentially dangerous contaminant that will volatilize during burning.
- Do not allow clothing, papers, or other flammables on the laboratory table where the burner is to be used.
- Store filled alcohol burners and fuel in an approved cabinet for flammable liquids.
- Never allow students to carry lighted burners.
- Use wide bottomed burners which are safer than tall, cylindrical ones.

Hot Plates

Hot plates are recommended as a source of heat particularly where volatile or flammable solvents are to be heated. An example is the classic extraction of chlorophyll often done in biology classes. If hot plates are to be used:

- Use of a three-pronged grounded receptacle is required for safe use.
- Use heating elements which are embedded rather than exposed.
- Ventilate heating elements to protect laboratory bench tops from burns.
- Perform extractions involving volatile and/or flammable solvents in the hood.

- Approved eye protection is required when using hot liquids.

Gas Burners

Several types of gas burners are available. The common laboratory or Bunsen burner may allow adjustment of only the air supply or of both the air and gas supply. Some burners allow adjustment of both air and gas. Safety points to be considered include:

- An identified master gas cut-off valve should be accessible in each laboratory where gas it to be used.
- The teacher should demonstrate correct procedures for lighting the burner and check each student's techniques.
- Gas lighters that produce a spark should be used rather than matches.
- Approved eye protection must be worn when burners are in use.
- Hair should be secured before lighting the burner.
- Students should be advised to avoid wearing loose and flowing clothing or scarves in the laboratory.
- Mecker or high temperature burners are designed for ashing operations in crucibles. They should not be used to heat test tubes.

ELECTRICAL EQUIPMENT

Electricity has no respect for ignorance. Students should be expected to respect certain absolutes in laboratories where electrical equipment is used.

- A master electrical cut-off should be accessible in each laboratory.
- Equipment with frayed cords should not be used. Be sure equipment is in proper working order before use.
- Three-pronged receptacles or plugs provide the protection of grounding. Lab grounding connections should be made to the building ground connections and school maintenance should regularly check the continuity of that ground connection.
- Ground fault circuit interrupters (GFI) must be installed near water supplies and wet locations.
- No work with electrical equipment should occur if floors are damp or wet.
- Students should not work on a model electrical circuit with the power turned on.
- Students should remain a safe distance from any project when it is turned on for the first time.
- Equipment turned off and disconnected can till contain a charge of electricity. Capacitors should always be shorted out with an insulated screw driver.
- Certain components such as resistors get hot while operating. Electrical components should be cool before removal.
- Electronic components, i.e. computers, printers, should not be operated with inadequate extension cords.

PERSONAL PROTECTION

Eye and face protection

Florida Statute requires the use of eye protective devices when students are engaged in certain activities.

FLORIDA STATUTE 232.45

Eye protective devices required in certain vocational and chemical laboratory courses.

(1) Eye protective devices shall be worn by students, teachers, and visitors in courses including, but not limited to, vocational or industrial arts shops or laboratories, at any time at which the individual is engaged in or observing an activity or the use of hazardous substances likely to cause injury to the eyes. Activity or the use of hazardous substances likely to cause injury to the eye include:
    a. Working with hot molten materials;
    b. Milling, sawing, turning, shaping, cutting, grinding, or stamping of any solid materials using power equipment
    c. Heat treatment; tempering or kiln firing of any metal or other materials;
    d. Gas or electric arc welding;
    e. Working with caustic or explosive materials;
    f. Working with hot liquids or solids, including chemicals which are flammable, caustic, toxic, or irritating.

(2) The school boards of the several districts may furnish plano safety glasses or devices for students and teachers, and shall furnish such equipment for all visitors to such classrooms or laboratories, or may purchase plano safety glasses or devices in large quantities and sell them at cost to students and teachers, but shall not purchase, furnish or dispense prescription glasses or lenses.

(3) To implement and carry out the purpose of this section, the school boards of the several districts are hereby given authority to promulgate rules and regulations to accomplish the purpose of the law.

In addition to the preceding statute, the following are recommended:

- Ventilated goggles that meet chemical splash protection standards should be worn by students.
- If contact lenses are to be worn in the laboratory, the student should notify the teacher, and be required to wear specially marked unventilated safety goggles.
- Student goggles should be sanitized after each use.

Clothing

- Vinyl or rubber aprons should be used to protect the body from chemical or thermal burns.
- Appropriate gloves should be worn when handling hazardous materials.
- **Students should wear closed-toed shoes.**
- Flowing or excessively loose clothing that could be caught in moving equipment or ignited by a burner should not be worn.
- Long hair should be tied back or confined in a net.

Clean up

- Tops of laboratory counters should be washed after each laboratory period.
- Students should wash their hands with soap before leaving the laboratory.

- Equipment should be cleaned and returned to its storage area.
- Aisles and traffic areas should be kept neat and unobstructed.

ASSEMBLING APPARATUS

- Keep work space uncluttered. Only authorized materials, instructions, notebook and pen or pencil should be present. Keep work space clear of chemicals and scraps of paper. Keep tall measuring equipment, such as glass cylinders, near the rear of the work space where they will not be easily knocked over.
- Set up clean, dry, approved apparatus firmly clamped and well back from the edge of the lab bench with due regard to the position of reagent bottles, burners, and to other students and their equipment. Choose sizes that can properly accommodate the experiment to be performed.
- Use only equipment that is free of flaws such as cracks, chips, frayed wire, and obvious defects. Discard all defective glassware.
- Freshly lubricate, properly support, and orient addition and separatory funnels so that the stopcock will not be loosened by gravity. A retainer ring or spring should be used on the stopcock plug.
- Support condensers with securely positioned clamps. The attached water hoses should be secured with wire or a clamping device.
- Position apparatus attached to a ring stand so that the center of gravity of the system is over the base, with adequate provision for removing burners or baths.
- Whenever possible, use hot plates or heating mantles in place of gas burners.
- Do not place apparatus or equipment on the floor of a working area in the laboratory.

Information for Physics, Physical Science and Earth Science Teachers

In general, laboratory experimentation in physics, physical science, and in earth science pose fewer hazards to students because of the limited exposure to chemical reagents and to living things. However, there are some hazards unique to the physics experimenters involving electricity, light and heat experiments.

Experiments with Electricity

- The instructor should check all circuits before applying power.
- Hands and feet should be dry when working with electrical circuits or electrical equipment.
- Capacitors should be discharged with an insulated screwdriver before handling.
- Power supplies should be appropriately grounded.
- Experiments with resistive heating may cause high temperatures. Caution should be used to avoid burns.
- Power should be off before making connections in an electrical circuit.
- Both hands should not contact a circuit. Use the rule of electricians: keep one hand in a picket while making adjustments with the other.
- The teacher should locate the master electricity cut-off switch and know how to use it.

- Be extremely cautious when demonstrating static electricity with the Van de Graff generator. Do not allow students to crowd around the apparatus, as accidental discharge may cause an involuntary reaction that may injure students standing nearby.
- Students should be cautioned that even common 110V household current can be lethal.

Experiments with Light

- Students should never look directly at the sun during a solar eclipse or when doing astronomical or spectrographic studies.
- When making observations through a spectroscope, telescope or pinhole camera, students should use indirect or projection methods.
- Appropriate ultraviolet protective safety goggles should be worn if black light or ultraviolet radiation experiments are done.
- Glass lenses, mirrors, or prisms should be examined for chips and sharp edges.
- Due to hazard of electrical shock, laboratory floors should be kept dry.
- Teachers should be aware that strobe lights can trigger seizures in certain susceptible people. Students should not look directly at the strobe.
- Gas discharge tubes can emit very energetic light when excited by Tesla coils or by standard power supplies. Know the kind of light that will be discharged and avoid those tubes that emit ultraviolet or X rays.
- When working with lasers, follow the safety instructions included with the laser. Never allow the laser beam to be directed into students' eyes.

Experiments with Heat

- Florida Statute states that eye protective devices must be used when students work with hot liquids or solids. This means that in science labs. Students must wear safety glasses, goggles or face shields whenever any material is heated, even water.
- Students with long hair should tie it back whenever heating with any open flame.
- Earth science experiments sometimes use incandescent heat lamps. Caution should be exercised, as the lamps can become hot enough to cause a burn. The area around the lamps must be kept dry to minimize the possibility of shock.
- Alcohol thermometers should be substituted for mercury thermometers. If a mercury thermometer breaks, follow the mercury spill control procedures in General Laboratory Techniques.
- Aneroid barometers should be substituted for mercury J-tube or manometers.

Experiments with Chemicals

- The Materials Safety Data Sheet on each chemical used in any experiment should be read for the precautions to be taken and the associated hazards. Refer to the section on Chemical Handling and Storage.
- Hydrochloric acid used for testing for carbonate rocks should be no more concentrated than a 10% solution.

- Volcano demonstrations using ammonium dichromate produce carcinogenic byproducts in the "ash" that floats around the room. This demonstration should not be performed. Substitute a bicarbonate of soda and vinegar "volcano".
- Safety goggles must be worn by students and the teacher whenever any chemical is used.
- Nuclear Regulatory Commission regulations should be followed when handling radioactive substances.
- Tongs or heavy leather gloves should be used when handling dry ice. The extremely cold temperature can cause severe skin damage. Prolonged breathing of the carbon dioxide vapor should be avoided, as asphyxiation can result.

Experiments with Model Rockets

- The use of model rockets requires a consideration of safety in several areas: construction, engines, flying conditions, launch, and recovery. Construction of the rocket should be of light weight, non-metal materials. Follow all instructions exactly and secure all joints carefully with glue. The rocket should be tested for stability before flight; the swing test may be used. Place a new engine in the rocket and tie a string around the middle of the rocket so that it is balanced. Swing the rocket in circles overhead. If the rocket goes around nose first, it is ready to fly. If it does not, then it is not stable and is not safe to fly. Use pre-loaded factory made model rocket engines as recommended by the manufacturer. Never use damaged or modified engines. To destroy a bad engine soak it in water until it falls apart. For the first flight use the smallest engine recommended by the manufacturer. Use only engines that will allow the rocket to land within the recovery area. Flying conditions must be considered so as to avoid a launch that could be dangerous to people or property. Do not launch in high winds, near buildings, power lines, tall trees or low flying aircraft. The launch pad should have a launch rod at least 3 feet long and a blast deflector to prevent the engine exhaust from starting a fire. There should be an electrical launching system with a cord that will reach at least 10 feet so that no one will be within 10 feet of the launch pad when the rocket is ignited. Designate a recovery crew to retrieve the rockets. They should be familiar with all of the safety rules and know the proper way to handle a rocket when returning it to the launch area.

Miscellaneous

- Eye protection should be used when "smashing" rocks in minerals or cleavage experiments. Small fragments can be deadly missiles and injurous to the unprotected eye of the student smashing the rock and his classmates.
- Ripple tanks and stream tables are massive pieces of equipment. They should be supported firmly so they do not fall.
- Physics field trips should follow the same safety precautions as any field trip.

RADIOACTIVE MATERIALS

The State of Florida Department of Health and Rehabilitative Services has approved the possession of small quantities of weak radioisotopes for educational purposes. Any

radioactive materials which can be legally purchased from a reputable and licensed distributor are legal to possess for classroom use. Report any accidents to the department chair, school administrator and science supervisor. Report any loss, theft, or damage to the school administrator. Information concerning radiation safety, accidents, and disposal of radioactive materials is available from the Florida Department of Health and Rehabilitative Services Office of Radiation Control.

Laboratory Safety Rules

- Know the primary and secondary exit routes from the classroom.
- Know the location of and how to use the safety equipment in the room.
- Work at your assigned seat/station unless obtaining equipment and chemicals.
- Do not handle equipment or chemicals without the teacher's permission.
- Follow laboratory procedures as explained and do not perform unauthorized experiments.
- Work as quietly as possible and cooperate with your lab partner.
- Wear appropriate clothing, proper footwear, and eye protection.
- Report all accidents and possible hazards to the teacher.
- Remove all unnecessary materials from the work area and completely clean up the work area after the experiment.
- Always make safety your first consideration in the laboratory.

SAFETY WEBSITES

General Safety Information and Protocol
http://www.flinnsci.com/Sections/Safety/generalSafety/stepsProve.asp
http://www.chem.unl.edu/safety/hslabcon.html

Chemical Safety - Storage
http://www.flinnsci.com/Sections/Safety/chemicalSafety/hazardousStorage.asp
http://www.nhsta.net/Safety/index.htm
http://www.csun.edu/science/ref/laboratory/safety/safety.html#storage

Chemical Safety – Usage
http://scied.gsu.edu/Hassard/mos/10.10.html
http://www.plymouthschools.com/Science/Curriculum/LABSAFTY.htm
http://user.fsd1.org/jlee/labsafety.htm

Safety Equipment – Room
http://mconn.doe.state.la.us/search.php?task=LP_view&lesson_id=1364&alttask=search_st&parent=LP&keyword=&subject=A&grade=A&dispPage=2&misc=22,24,26

Safety Equipment – Student Use
http://www.carnegieinstitution.org/first_light_case/horn/labsafety.html
http://safety.lovetoknow.com/Middle_School_Lab_Safety_Activities
http://www.chem.unl.edu/safety/hslabcon.html
http://www.fifeschools.com/cjh/staff/laker/labsafety.htm

http://www.williamsclass.com/MainSitePages/LabSafety.htm
http://www.austinisd.org/academics/curriculum/subjects/science/safety02.phtml
http://ehs.fullerton.edu/StudentSafety/

Use of a Fume Hood
http://www.chem.unl.edu/safety/hslabcon.html
http://www.austinisd.org/academics/curriculum/subjects/science/safety02.phtml

Safety Shower
http://www.chem.unl.edu/safety/hslabcon.html
http://www.austinisd.org/academics/curriculum/subjects/science/safety02.phtml

Fire Safety
http://www.chem.unl.edu/safety/hslabcon.html
http://www.austinisd.org/academics/curriculum/subjects/science/safety02.phtml

Glass Safety
http://www.chem.unl.edu/safety/hslabcon.html
http://www.austinisd.org/academics/curriculum/subjects/science/safety02.phtml

Gas Safety
http://www.chem.unl.edu/safety/hslabcon.html
http://www.fifeschools.com/cjh/staff/laker/labsafety.htm

Emergency Supplies
http://www.nsela.org/publications/publications2.html