FLINN SCIENTIFIC

Safety Reference

Start with **Safety**

The ability to work with students in the lab—allowing them to observe, question, engage and discover—is one of the most rewarding aspects of any science teacher's responsibilities. It is also potentially one of the most dangerous. The purpose this article is to provide a forum for science teachers to review safety requirements and procedures, discuss their safety concerns and set goals to improve safety. Understanding their safety roles and responsibilities will help science teachers increase safety awareness, reduce accidents and improve science education.

General Safety Responsibilities

Science teachers owe it to their students to care about anticipating dangers that are reasonably foreseeable and to take the necessary precautions to prevent accidents and protect students from harm. The teacher's responsibilities include the following:

- Supervising students in the classroom and lab.
- Providing adequate instructions for students to perform the tasks required of them.
- Warning students of the possible dangers involved in performing lab activities.
- Providing safe laboratory facilities for performing experiments and demonstrations.
- Maintaining laboratory equipment in proper working order.

The Flinn Scientific Student Safety Contract was developed in collaboration and consultation with experienced science teachers from all across the country. This comprehensive safety contract is available in high school and middle school versions in both English and Spanish. Visit our website at www.flinnsci.com.

The Safety Contract

The first step in creating a safe laboratory environment is to develop a safety contract that describes the rules of the laboratory that your students must follow. The safety contract is the foundation of any school science safety program. Before a student ever sets foot in the lab, the safety contract should be discussed in class and then signed by the student and a parent or guardian. Review the rules not just the first day of class, but on a regular basis. Incorporate safety into each class or laboratory exercise—begin every lab period, in particular, with a discussion of the procedures or chemicals used in the experiment and the general and special safety precautions that must be observed. Prelab assignments are another way to ensure that students are prepared for lab and understand the safety requirements.

Proper instruction is not just for beginning students. Imagine that you are teaching a senior biology elective—should you assume that students know how to use a Bunsen burner to sterilize an inoculating loop?

Supervision

Teachers must be physically present at all times to supervise students wherever and whenever laboratory equipment or chemicals are being used. Never leave students unattended—be prepared and remain alert to what students are doing in order to prevent accidents before they happen. The best defense is a good offense!

Proper Instruction

It is insufficient to merely give students lab directions or procedures in the form of a handout or textbook reading assignment. Proper instruction requires that teachers explain the nature of the equipment or chemicals that students will be using and how they are to perform tasks in the lab. Proper instruction also includes demonstrating new or unusual laboratory procedures and teaching students the safe way to handle chemicals, glassware and other equipment. Remember to record all safety instruction in your lesson plans. Being able to provide evidence of documented safety instruction reduces your liability in the unlikely event of an accident.

Warning Students of Hazards

Teachers have a responsibility to specifically identify hazards and warn students about the possible dangers of working with chemicals or performing tasks in the lab. Consider the following chemical hazard warning: Hydrochloric acid is corrosive—avoid contact with eyes and skin. What is the first thing students think of when they hear the term corrosion? Rust! Students do not always understand the proper meaning of hazard warnings or safety precautions. Warning students requires showing them what these words mean in the context of lab safety. Just as with any instruction, it is important to demonstrate the concepts and to assess student understanding of the safety concepts.

Maintaining a Safe Lab Environment

The school administration and science teachers share a responsibility to maintain a safe lab environment for students. The school must provide safety equipment that is appropriate for the hazards and maintain the equipment in proper working order. The science teacher's duty of care in this respect is to communicate with the administration, keep them informed about the safety requirements, recommend safety equipment, practices and procedures and inspect safety equipment on a regular basis. All equipment and glassware must be in good working order before it is used in the lab. Inspect equipment before setting it out for student use, and remove any defective materials. Instruct students to check glassware regularly for cracks and chips, especially if glassware will be heated or subjected to pressure differences (e.g., vacuum).

Helping Students Meet Their Responsibilities

Students are required to follow all rules, guidelines and instructions provided by the school district and their teacher. Signing the safety contract signifies that students have read the contract, understand the rules and agree to abide by the safety requirements in the school science laboratory. The safety contract should also be signed by a parent or guardian to document that they are aware of the rules their child must follow and the potential consequences of not following them. Students have a responsibility to come to class prepared for the laboratory activity. One of the leading causes of laboratory accidents is students' failure to carefully read and understand lab instructions. Students must wear all the required personal protective equipment, including safety glasses or chemical splash goggles and chemical-resistant gloves and aprons, as instructed by the teacher.

FLINN LOVE ♥

I'm so impressed with your efforts to make our instruction easier and provide us with such helpful resources, such as the safety video on quality lab materials. I will continue to order from Flinn from now on!

MONA ALKADI
LOUISIANA SCHOOL FOR THE DEAF, LA

Chemical Safety **in the Lab**

Make Your Lab a Safer Place to Work and Teach

The overall safety profile of your school will be drastically improved if you adopt and follow carefully written purchasing specifications for laboratory chemicals. Your goals should be to establish uniformity and high standards with respect to the information shown on the chemical label, the type of chemical packaging used and the amount of chemical purchased.

Chemical Labeling

Begin by specifying that certain information be clearly shown on all chemical bottle labels. The required information should include:

- Chemical Name, Grade, Purity and Concentration
- Hazard Alert
- A Chemical Safety Guide showing what safety aids should be available when using the chemical
- Warning Information
- First Aid Procedures
- Lot Number
- Compatible Chemical Storage Family
- Suggested Disposal Method
- Shelf Life
- Solubility
- Date Purchased
- CAS Number
- NFPA Code

A consistent labeling system makes proper storage and maintenance of your chemical inventory much easier. It also helps you to quickly identify hazards and proper safety procedures.

Flinn Scientific is the only science supply company that provides such comprehensive labeling on its chemicals. The Flinn chemical safety label has been specifically designed to fit the needs of the middle and high school science teacher. The above specifications will help you acquire the quality product you expect and the safety information you need.

Chemical Packaging

The second category to incorporate into your chemical purchasing specifications is the safety packaging of the chemicals. Chemicals must be supplied in packaging designed to give the chemical and the user maximum protection. The packaging should maximize the chemical's freshness and shelf life. Flinn also uses packaging that will reduce or eliminate expensive hazard shipping charges.

Incorporate chemical packaging concerns into your purchasing considerations. Does the supplier package most chemicals in safe plastic containers, versus glass bottles, which can be broken? All Flinn chemicals are packaged in unbreakable plastic bottles or PVC-coated glass containers for safety.

The type of container in which a hazardous chemical is packaged may determine whether you purchase the chemical in the first place. For instance, most chemical suppliers package magnesium ribbon in a wax paper bag. Flinn Scientific packages it in an air-tight zipper-lock bag to prevent the magnesium ribbon from oxidizing.

Does your supplier offer acids in safer, PVC-coated bottles? Does your supplier package small, precut pieces of sodium or potassium under mineral oil in PVC-coated glass bottles and then in a metal can for safer storage? Flinn Scientific's state-of-the-art chemical packaging containers are the safest in the industry.

Chemical Package Sizes

Does your chemical supplier offer smaller chemical package sizes so you can purchase only the quantity you actually need? Excess chemicals sitting on your shelves year after year increase your overall storage risks, tie up valuable budget dollars, create hazardous clutter and result in costly disposal methods.

The shelf life of your chemicals is an important concern. Some chemicals become more hazardous with age. Purchasing in small quantities allows you to have new, "fresh" chemicals on the shelf at all times. It is recommended to mark any chemical labels with the purchase date. Having this information available helps you know how old your chemicals are and if a shelf life problem exists.

Yes, safety has its costs, but these costs are always short term! In the long run, purchasing chemicals in smaller package sizes saves you money because you are storing less material, ultimately leading to lower disposal costs. You might even save money on insurance premiums—some insurance companies may offer lower premiums to schools that have adopted chemical purchasing practices designed to promote safety.

Flinn Scientific has more than 500 chemicals available in small package sizes.

Conclusion

Purchasing chemicals is not like buying finger paints or copier paper. You need to establish uniformity among the chemicals you purchase, use and store. When you buy chemicals from ten different companies you are going to get ten different levels of quality. This all adds up to confusion for your science department staff and lowers your school's overall safety standards.

If you are serious about getting your "chemical act" together, look at more than just the price of the chemicals you purchase. What does one chemical accident cost in terms of lost time, cleanup, injury and in today's world—litigation? Will a court of law have sympathy for your school when an accident occurs and they find out that you purchased a "lesser quality" chemical package because it was $1.17 cheaper than the package you should have purchased? You must ask yourself if the money saved is worth the increased risk.

Improve the overall safety profile of your school by adopting stringent purchasing specifications for your laboratory chemicals. Not all chemicals are equal in quality, packaging or labeling. Science teachers can obtain laboratory chemicals that are properly packaged and labeled if the purchasing specifications are carefully written with the science teachers' and students' safety in mind. Flinn Scientific's suggestions for chemical packaging specifications help the safety conscious science teacher achieve the goal of obtaining chemicals provided in "safe to use" chemical containers, properly labeled and at a competitive price.

Please ask yourself the question, "In the best interest of my students and teaching staff, where can I purchase laboratory chemicals with specialized chemical safety packaging and labeling?" The answer is Flinn Scientific! Discover why Flinn Scientific is truly your "Safer Source" for laboratory chemicals. Purchase your chemicals from Flinn Scientific and help make your laboratory a safer place to teach and learn.

No Need to Repackage

Flinn sodium is packaged ready-to-use and ready-to-store. Five small pieces of sodium (0.3–0.5 g each), perfect for demonstrations, are packaged under mineral oil in a plastic bottle. The bottle is placed in a plastic bag within a metal can for safer storage. Count on Flinn for the safest package.

How to Read a **Safety Data Sheet (SDS)**

Safety Data Sheets (SDSs) are an important requirement of the OSHA Hazard Communication Standard. SDSs are essential documents that are used to inform employees, students and the general public about how materials can be safely handled, used and stored. Since Flinn provides chemicals only to schools, we have written Flinn SDSs specifically for teachers and their students. Using clear and straightforward language, each Flinn SDS provides all the relevant safety and hazard information in a consistent, useful and easy-to-read two-page format. Flinn SDSs follow the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). The 16 sections are divided into four major areas, each designed to answer a specific question.

What is the material and what do I need to know immediately in an emergency?

Sections 1–3

A It is important that the chemical name on the label match the name on the SDS. Many chemicals have similar names but very different properties.

B The most important section! It provides an overview of the physical and health hazard risks associated with using the material.

C Signal words, either Danger or Warning, heighten the awareness of the relative risk when using certain chemicals. Danger is the more severe warning!

D Nine pictograms exist in the GHS classification scheme to call attention to physical and health hazards. See page 702 for more information about GHS pictograms.

E This section includes the formula, formula weight, concentration and CAS No. The CAS No. is the single identifying number for each specific substance. The CAS No. should match the CAS No. on the bottle label.

What should I do if a hazardous situation occurs?

Sections 4–6

F Seek medical attention. These first-aid measures are only meant for immediate first aid and should always be followed up with professional medical care.

G This section is written for the firefighter. Flash point (the lowest temperature at which enough vapor is present to form an ignitable mixture with air); upper and lower flammable limits; and the auto ignition temperature (AIT) are common properties included in this section.

FLINN SCIENTIFIC, INC.
Safety Data Sheet (SDS)

SDS #: 181.00
Revision Date: September 25, 2022

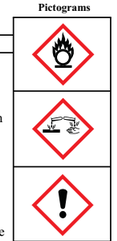
SECTION 1 — CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

n-Butyl Alcohol (A)

Flinn Scientific, Inc. P.O. Box 219 Batavia, IL 60510 (800) 452-1261
CHEMTREC Emergency Phone Number: (800) 424-9300

(C) **Signal Word** DANGER

(D) Pictograms



SECTION 2 — HAZARDS IDENTIFICATION

Hazard class: Flammable liquids (Category 3). Flammable liquid and vapor (H226). Keep away from heat, sparks, open flames, and hot surfaces. No smoking (P210). (B)

Hazard class: Acute toxicity, oral (Category 4). Harmful if swallowed (H302). Do not eat, drink or smoke when using this product (P270).

Hazard class: Skin corrosion or irritation (Category 2). Causes skin irritation (H315).

Hazard class: Serious eye damage/eye irritation (Category 1). Causes serious eye damage (H318).

Hazard class: Specific target organ toxicity, single exposure; respiratory tract irritation (Category 3). May cause respiratory irritation (H335).

Hazard class: Specific target organ toxicity, single exposure; Narcotic effects (Category 3). May cause drowsiness or dizziness (H336). Avoid breathing mist, vapors or spray (P261).

SECTION 3 — COMPOSITION, INFORMATION ON INGREDIENTS

Component Name	CAS Number	Formula	Formula Weight	Concentration
n-Butyl alcohol (E)	71-36-3	$CH_3(CH_2)_2CH_2OH$	74.12	
Synonym: 1-Butanol; n-Butanol				

SECTION 4 — FIRST AID MEASURES

Call a POISON CENTER or physician if you feel unwell (P312). (F)
If inhaled: Remove victim to fresh air and keep at rest in a position comfortable for breathing (P304+P340).
If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing (P305+P351+P338).
If on skin (or hair): Immediately remove all contaminated clothing. Rinse skin with water (P303+P361+P353).
If swallowed: Rinse mouth. Call a POISON CENTER or physician if you feel unwell (P302+P301+P312).

SECTION 5 — FIRE FIGHTING MEASURES

Class 1C flammable liquid.
Flash point: 37 °C Flammable limits: Lower: 1.4% Upper: 11.2% Autoignition Temperature: 343 °C
When heated to decomposition, may emit toxic fumes.
In case of fire: Use triclass dry chemical fire extinguisher (P370+P378). (G)

NFPA CODE (H)
H-2
F-3
R-0

SECTION 6 — ACCIDENTAL RELEASE MEASURES

Remove all ignition sources and ventilate area. Contain the spill with sand or other inert absorbent material and deposit in a sealed bag or container. See Sections 8 and 13 for further information. (I)

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H The NFPA code is a numerical code established by the National Fire Protection Association (NFPA). It rates the substance *under fire conditions* in four categories. **H**ealth, **F**lammability, **R**eactivity and **U**nusual reactivity: 4 is a severe hazard; 0 is no hazard.

I How to clean up a spill. Always remove unprotected personnel from the area and make sure all students are safe. Contain the spill with sand or absorbent materials.

HOW TO READ A SAFTEY DATA SHEET (SDS) continued on next page.

How to Read a Safety Data Sheet (SDS), continued

Each Flinn SDS follows the same format, and the information is always found in the same location, making it a valuable resource in the event of an emergency. With your first chemical order of the year, every teacher will receive a CD from Flinn Scientific containing all of our SDSs. You may also request another CD at any time. Flinn SDSs are updated on a regular basis, guaranteeing the most up-to-date safety information possible. Flinn sells a complete SDS Library in two versions, a hard copy version in two binders (Catalog No. AP7703, page 675) or as part of the Flinn Online Chemventory™ program. For a more detailed description of the Flinn Online Chemventory™ program, please refer to pages 668–669. For our customers' convenience, Flinn has also placed a free complete set of digital versions of all the SDSs on our website. Simply go to www.flinnsci.com and click on the *SDS* button—individual SDSs are easy to find and copies may be printed from your computer.

FLINN SCIENTIFIC, INC.
Safety Data Sheet **n-Butyl Alcohol**

SDS #: 181.00
Revision Date: September 25, 2022

SECTION 7 — HANDLING AND STORAGE

Flinn Suggested Chemical Storage Pattern: Organic #2. Store with alcohols, glycols, amines, and amides.
Store in a dedicated flammables cabinet. If a flammables cabinet is not available, store in Flinn Saf-Stor™ can. (J)
Keep container tightly closed (P233). Keep cool (P235). Use only in a well-ventilated area or in a hood (P271).

SECTION 8 — EXPOSURE CONTROLS, PERSONAL PROTECTION

Wear protective gloves, protective clothing and eye protection (P280). Wash thoroughly after handling (P264). Use ventilation to keep airborne concentrations below exposure limits.
Exposure guidelines: PEL 100 ppm (OSHA) TLV 20 ppm (ACGIH) (K)

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

Clear colorless liquid. Wine-like odor.
Soluble: Water (20%). Miscible with alcohol and ether. (L)

Boiling point: 117.7 °C
Melting point: -89 °C
Refractive index: 1.3988
Specific gravity: 0.81

SECTION 10 — STABILITY AND REACTIVITY

Avoid contact with aluminum, chromium trioxide, and oxidizing materials.
Substance may develop explosive hydroperoxides. (M)
Shelf life: Fair, substance may oxidize. See Section 7 for further information.

SECTION 11 — TOXICOLOGICAL INFORMATION

Acute effects: Absorbed through skin. Eye, skin, respiratory tract irritation. Dizziness. CNS depression.
Chronic effects: N.A.
Target organs: Eyes, skin, respiratory system, central nervous system. (N)

ORL-RAT LD_{50}: 790 mg/kg
IHL-RAT LC_{50}: 8000 ppm/4H
SKN-RBT LD_{50}: 3400 mg/kg (O)

N.A. = Not available, not all health aspects of this substance have been fully investigated.

SECTION 12 — ECOLOGICAL INFORMATION

Data not yet available. (P)

SECTION 13 — DISPOSAL CONSIDERATIONS

Please review all federal, state and local regulations that may apply before proceeding.
Flinn Suggested Disposal Method #18b is one option. (Q)

SECTION 14 — TRANSPORT INFORMATION

Shipping name: Butanols. Hazard class: 3, Flammable Liquid. UN number: UN1120.

N/A = Not applicable (R)

SECTION 15 — REGULATORY INFORMATION

TSCA-listed, EINECS-listed (200-751-6), RCRA code U031. (S)

SECTION 16 — OTHER INFORMATION

This Safety Data Sheet (SDS) is for guidance and is based upon information and tests believed to be reliable. Flinn Scientific, Inc. makes no guarantee of the accuracy or completeness of the data and shall not be liable for any damages relating thereto. The data is offered solely for your consideration, investigation, and verification. The data should not be confused with local, state, federal or insurance mandates, regulations, or requirements and CONSTITUTE NO WARRANTY. Any use of this data and information must be determined by the science instructor to be in accordance with applicable local, state or federal laws and regulations. The conditions or methods of handling, storage, use and disposal of the product(s) described are beyond the control of Flinn Scientific, Inc. and may be beyond our knowledge. FOR THIS AND OTHER REASONS, WE DO NOT ASSUME RESPONSIBILITY AND EXPRESSLY DISCLAIM LIABILITY FOR LOSS, DAMAGE OR EXPENSE ARISING OUT OF OR IN ANY WAY CONNECTED WITH THE HANDLING, STORAGE, USE OR DISPOSAL OF THIS PRODUCT(S). (T)

Consult your copy of the *Flinn Science Catalog/Reference Manual* for additional information about laboratory chemicals.

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R Department of Transportation shipping information is included for your school district, emergency responders and transport/shipping departments.

S This includes regulatory information used by regulatory compliance personnel.

How can I prevent hazardous situations from occurring?

Sections 7–11

J Use the Flinn Suggested Chemical Storage Pattern to prevent accidents and improve safety. Special storage and usage tips are also included.

K Wear personal protective equipment, such as goggles, gloves and an apron. See page 689 for an explanation of any exposure guidelines.

L Clear, concise and useful physical and chemical properties help you learn more about the chemicals you use. The first part describes the material's appearance. If it doesn't look like this, STOP. Do not use it. It may be more or less hazardous.

M This describes the conditions or reactions to be avoided and also provides some indication about anticipated shelf life.

N Here is more detail on how the material may injure you. Acute (short exposure) and chronic (long-term) effects are listed along with their target organs.

O Oral (ORL), inhalation (IHL) and skin absorption (SKN) toxicity data on test animals is included. For more information on LD_{50}, see pages 692–693.

Other useful information.

Sections 12–16

P Ecological impact if large amounts (e.g., tank car) of the chemical spill near a river or lake.

Q We offer suggested disposal methods for laboratory quantities of chemicals. See pages 736–753 for explanations of the Flinn Suggested Disposal Methods.

T Flinn Scientific has an ongoing program to update its SDSs. As professional chemists, we try our best to provide science teachers with the most accurate and useful safety information. Call Flinn with any questions. We can help!

Right-to-Know Laws* or **Hazard Communication Standards**

There is some confusion about the use of hazardous chemicals in schools and about how the relevant "Right-to-Know" laws apply to schools. Let's set the record straight for public schools. The U.S. government has passed the Hazard Communication Standard (usually referred to as the "Right-to-Know" law) and the Laboratory Standard, but these laws do not extend coverage to state and local governments. However, almost all state governments have either passed their own version of the Hazard Communication Standard or put their stamp of approval on the federal laws and extended their jurisdiction to cover local and state governmental bodies—including public schools. Federal jurisdiction does apply to all private schools.

The purpose of these laws is to inform employees about any hazards associated with an employee's work. Employees have the "Right-to-Know" about all the hazards they might deal with in the workplace.

Flinn Scientific is Your Safer Source...

Flinn will help you meet all the requirements of the Right-to-Know laws with easy-to-use and affordable solutions. From the teacher favorite *Flinn Scientific Catalog/Reference Manual* to the informative Flinn website at www.flinnsci.com to our helpful Technical Services department, you are never more than a phone call (800-452-1261) or email (flinn@flinnsci.com) away from the best safety advice available. We have more than 40 years of experience helping teachers solve their safety problems, so let us help you meet your legal requirements of the Right-to-Know Laws.

GHS Revision

In March 2012, OSHA published the first major revision to the Hazard Communication Standard since its inception. In announcing the revision to incorporate what is known as GHS, OSHA stated that its goal was to transform the "Right-to-Know" into the right to understand chemical hazards. GHS stands for the Globally Harmonized System of Classification and Labeling of Chemicals. GHS is a document that establishes objective criteria for classifying and identifying chemical hazards. The overarching goal is to ensure the safe use of chemicals by providing practical, reliable and comprehensible information on their hazards. GHS provides a set of objective criteria for classifying the physical and health hazards of chemicals. To remove ambiguity about the degree of risk inherent in using a chemical, GHS further specifies the use of standard symbols and language elements to convey the hazard information on chemical labels. Hazardous chemical labels are now required to include pictograms, a signal word and specific hazard and precautionary statements.

Major Requirements

The federal and most statutory Right-to-Know laws contain the following six requirements or provisions.

1. Safety Data Sheets (SDSs)

SDSs are the primary way of communicating the hazards of a chemical to an employee or an employer. The SDS provision of the law requires the employer to acquire, update and maintain SDSs for all of the hazardous chemicals used or stored in the facility and to make those SDSs available to the employee for informational purposes.

The minimum standards for an SDS include:

- Written in English
- Chemical name
- Hazards identification with GHS signal word, pictograms, hazard class and applicable hazard statements
- Hazardous components
- Physical characteristics (e.g., density, flash point)
- Physical hazards (e.g., fire, explosion, reactivity)
- Health hazards (both chronic and acute)—All signs or symptoms of exposure must be listed. Carcinogens must be identified.
- Primary routes of entry and target organs
- Permissible exposure limits or Threshold Limit Value (TLV)
- Any applicable precautions (e.g., gloves, goggles, fume hood)
- First aid and emergency procedures (e.g., chemical splash, spill handling)
- Date prepared
- Name and address of the manufacturer or SDS preparer, including the phone number

2. Hazardous Materials List

A list of all hazardous chemicals must be assembled. In most states, this list is kept only by the employer, and access is given to the employee upon request. Some states require a copy of this list to be given to the fire department or some other state agency. See the state-by-state breakdown of the Right-to-Know laws on page 690 for further details.

3. Inventory

The hazardous materials list and an up-to-date inventory usually go hand in hand. Both the list and the inventory must be continually updated. An inventory of all hazardous chemicals is an essential requirement of most Right-to-Know laws. An inventory consists of the name of the chemical, how much you have and where it is stored.

4. Notification

All laws require the employer to notify the employee of any potential exposure or actual exposure to a hazardous substance. This initially is accomplished by posting the Right-to-Know regulations on a poster where it easily can be read and will be noticed by the employee. Notification is also accomplished through training and employee access to SDSs.

Flinn Is Your Source for Safety Training

Annual safety training is required in most states. Flinn Scientific trains more than 5,000 teachers every year through the Flinn Scientific Laboratory Safety Seminars. This safety seminar is also available as a fast-paced, two-hour video that is perfect for in-service programs or new teacher training. To help satisfy annual training requirements, Flinn provides free monthly safety training through the Flinn Science Department Safety Training Notes. These safety notes are sent out every month via email. To receive this valuable training aid, please call Flinn or sign up on our website at www.flinnsci.com.

Many teachers consider the *Flinn Scientific Catalog/Reference Manual* their "safety bible" and use it as the source of their informal safety training. The Flinn technical staff also writes numerous safety articles every year that are emailed to our customers or available on the Flinn website. Count on Flinn for your safety training needs.

* The Right-to-Know law summary information listed here was obtained from reliable sources. For more information, go to www.flinnsci.com/safety for the name and address of the agency in your state that regulates these laws and standards.

RIGHT-TO-KNOW LAWS OR HAZARD COMMUNICATION STANDARDS continued on next page.

Right-to-Know Laws, continued

5. Training

Many state laws are very detailed and specific in the area of training requirements of employees. Most states require training to be done annually or when exposure to a new hazard is anticipated. Some states require this training to be in written form while others allow verbal training or some combination of both types. Training includes:

a. Learning to read labels and SDSs
b. Providing the locations of hazardous materials
c. Learning the hazards, both chronic and acute, associated with the materials in the workplace
d. Safe handling of chemicals
e. Using protective equipment (e.g., fire extinguishers, respirators)
f. Knowing first aid and emergency procedures (e.g., spills, exposure, splashes)

6. Labels and Labeling of Hazardous Materials

Most laws require that a minimum standard of labeling must be observed. This includes:

- Chemical name, concentration, target organ, effect and date prepared.
- Hazards, both physical and health.
- Hazards identification with GHS signal word, pictograms, hazard class and applicable hazard and precautionary statements.
- Name and address of the manufacturer.

All states indicate that if the product is purchased and the label meets the standard, no further labeling is necessary.

Flinn **Online Chem**ventory™

FLINN EXCLUSIVE

Chemical Inventory Management System

The Flinn Online Chemventory™ is a cloud-based laboratory chemical inventory system that allows multiple users access to the database from multiple locations and multiple devices! Maintaining an accurate laboratory chemical inventory has never been easier, more flexible and more convenient.

Catalog No.	Description	Price/ Database License
SE2998	Flinn Online Chemventory™, 1-Year License	$ 99.00
SE2999	Flinn Online Chemventory™, 3-Year License	249.00
SE3000	Flinn Online Chemventory™, 5-Year License	349.00

The Chemical Hygiene Plan

In May 1990, the federal government passed an extension of the Hazard Communication Act written specifically for the research and academic laboratory. Most states also passed a version of the Laboratory Standard. Enforcement of the new Laboratory Standard began in January 1991. The Laboratory Standard is very similar in many ways to the original law. The major difference is the requirement to have a Chemical Hygiene Plan and a Chemical Hygiene Officer.

A Chemical Hygiene Plan (CHP) is a written report summarizing all your safety regulations, proper laboratory procedures for handling hazardous chemicals and training procedures. The CHP should include:

- General laboratory rules and procedures
- Personal protective equipment requirements
- Spill and accident procedures
- Chemical storage rules and procedures
- Safety equipment requirements and inspection procedures
- Employee safety training
- Exposure and medical evaluations
- Emergency evacuation plan

The CHP's listing of rules and procedures are your Standard Operating Procedures. These rules and procedures must be well thought out with the principal goal of always minimizing the exposure of employees and students to hazardous chemicals.

Flinn CHP Has Helped Thousands of Teachers

Developing a Chemical Hygiene Plan (CHP) does not have to be difficult. Thousands of schools have created their own individualized CHP starting with the Flinn Scientific Chemical Hygiene Plan as a model or template. This multi-page CHP model plan is available free from Flinn Scientific. It contains the basic safety laboratory regulations and procedures and is easy to alter to meet your individual school's needs. For a free copy of this important document, as either a paper hard copy or a Microsoft Word® document, send your request to Flinn Scientific, Inc., P.O. Box 219, Batavia, IL 60510. For an electronic version, please email us at flinn@flinnsci.com and request the CHP Word document.

Conclusion

The various state Right-to-Know laws are all very similar. The six major requirements or provisions discussed here are always included along with minor modifications concerning who must be trained and how and to whom you will have to send SDSs and hazardous materials lists. The paperwork requirements (SDS and reporting lists) can be overwhelming, but they are mandated by the laws. The science teacher's five major steps include:

1. Take an inventory (develop a list of hazards).
2. Acquire, update and maintain SDSs.
3. Label all chemicals properly.
4. Train.
5. Develop a Chemical Hygiene Plan.

Following these five steps will not only help you comply with your respective state's Right-to-Know law, but it will also improve the safety in your classroom.

RIGHT-TO-KNOW LAWS OR HAZARD COMMUNICATION STANDARDS continued on next page.

Right-to-Know Law Analysis

State	Chemical Hygiene Plan	SDS Required	List/Inventory Required	Training Required	Labeling Required	Special Comments
Federal OSHA	✓	✓	✓	✓	✓	
Alabama	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Alaska	✓	✓	✓	✓	✓	Very similar to the Federal OSHA Standard
Arizona	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Arkansas	✓	✓	✓	✓	✓	Written hazard communication program required
California	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Colorado	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Connecticut	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Delaware	No	✓	✓	✓	✓	An employee Right-to-Know Law
District of Columbia	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Florida	✓	✓	✓	✓	✓	Requires providing a list of hazardous materials to fire department
Georgia	No	✓	✓	✓	✓	Written school safety plan required
Hawaii	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Idaho	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Illinois	✓	✓	✓	✓	✓	Notify your fire department regarding any toxic materials
Indiana	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Iowa	✓	✓	✓	✓	✓	Follows Federal OSHA Standard; requires a written training program
Kansas	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Kentucky	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Louisiana	✓	✓	✓	✓	✓	Requires an emergency response guidebook
Maine	✓	✓	✓	✓	✓	Requires a written training and hazardous communication program
Maryland	✓	✓	✓	✓	✓	Requires a list of hazardous materials sent to the MD Department of Environment
Massachusetts	No	✓	✓	✓	✓	Written hazard communication program recommended
Michigan	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Minnesota	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Mississippi	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Missouri	✓	✓	✓	No	No	Provide SDS to fire department
Montana	✓	✓	✓	✓	✓	A list of hazardous materials provided to the county
Nebraska	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Nevada	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
New Hampshire	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
New Jersey	✓	✓	✓	✓	✓	A hazardous materials list submitted to the NJ Department of Health
New Mexico	✓	✓	✓	✓	✓	Requires the written hazard communication program
New York	✓	✓	✓	✓	✓	Requires the written hazard communication program
North Carolina	✓	✓	✓	✓	✓	Given to your fire department for large quantities of chemicals on premises
North Dakota	No	✓	✓	✓	✓	Requires a written training and hazardous materials communication program
Ohio	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Oklahoma	✓	✓	✓	✓	✓	Requires a written training program; requires the CAS number be on the label
Oregon	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Pennsylvania	✓	✓	✓	✓	✓	Give a list of the hazardous materials to your fire and police departments
Rhode Island	✓	✓	✓	✓	✓	Hazardous materials list must be sent to RI Deptartment of Labor and fire department
South Carolina	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
South Dakota	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Tennessee	✓	✓	✓	✓	✓	Similar to the Federal OSHA Standard
Texas	No	✓	✓	✓	✓	May provide SDS or a list of hazardous agents to your fire department
Utah	✓	✓	✓	✓	✓	Requires a written hazard communication program
Vermont	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Virginia	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Washington	✓	✓	✓	✓	✓	Requires a written hazard communication program
West Virginia	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard
Wisconsin	✓	✓	✓	✓	✓	An employee Right-to-Know Law
Wyoming	✓	✓	✓	✓	✓	Identical to the Federal OSHA Standard

Goggle **Safety**

What Do the ANSI Standards Really Mean?

Appropriate eye protection is extremely important in the science classroom. As you compare the wide array of goggles and safety glasses, you often see the phrase "Meets ANSI Z87+ Standards." In the *Flinn Scientific Catalog/Reference Manual*, we list several eyewear styles, all of which meet the ANSI standard. Obviously, there must be more to choosing safe eyewear than merely picking any style that meets this standard. To choose the most suitable eyewear for yourself and your students, it is helpful to understand ANSI and its relationship to school laboratory regulations.

What Is ANSI Z87+?

The American National Standards Institute (ANSI) is a nonprofit association that publishes standards covering a broad range of equipment and industries. The complete title of the current ANSI document pertaining to eyewear is American National Standard for Occupational and Educational Personal Eye and Face Protection, ANSI Z87.1–2010. This document includes standards for several different styles of safety eyewear ranging from eyeglass-type spectacles to heavy-duty welding helmets. The document is organized according to the hazards that might be faced and allows an instructor or employer to select the appropriate safety eyewear based on the hazards they expect to encounter. These hazards include impact and coverage, droplet/splash, dust, fine dust and optical radiation. The previous versions of this standard did not include tests to determine protection against splash, dust or fine dust.

For a clear understanding of how these standards relate to your choice of laboratory eyewear, it is helpful to know more about ANSI and Z87+.

Popular Flinn Visor Goggles offer comfort and coverage (see page 665).

- ANSI is not a federal agency. As an independent association, it is not involved in establishing or enforcing the OSHA Laboratory Standard.
- ANSI does not test, inspect or approve eyewear. The eye protection manufacturer can choose to contract an independent testing facility to conduct tests to determine whether their products meet ANSI standards.
- There are important factors that are difficult to measure and are not covered in Z87+ that must be considered when choosing eyewear. Among these are durability, comfort and antifog performance.

The easiest way to determine the type of protection the eyewear provides is to look at the frames of the goggles. Molded into each frame is a series of letters and numbers that refer to the level of protection the eyewear is certified.

- Z87—The eyewear meets the basic criteria of the standard.
- Z87+—The eyewear is able to withstand the impact of a high-velocity projectile without compromising user's safety.
- D3—The eyewear protects the eyes and face from droplets and splashes.
- D4—The eyewear protects against dust.
- D5—The eyewear protects against fine dust (vapor).

An example of the markings you can expect to see on a goggle frame that protects against splash and high impact is Z87+D3.

Keep in mind that not all eyewear is created equal. There are a lot of cheaply made goggles on the market that will not survive even one semester. Still, how safe are goggles that meet ANSI standards but will be left in a desk drawer, unworn, because they are broken or uncomfortable?

- Eyewear should fit comfortably and securely. Try different styles and sizes to find the right fit.
- Chemical splash goggles should have a soft, pliable flange that seals around the eyes. The hard plastic edge on models lacking a flange becomes extremely uncomfortable.
- Availability of replacement parts (e.g., headbands, lenses, vent covers) is a real cost-saving advantage.
- Antifog performance is affected by temperature and humidity. Experiment with different eyewear styles and features (vented and fog-free lenses) to find the best eyewear for your classroom.

The Choice Is Up to You

As a responsible science teacher, you must select eyewear that provides you and your students the most suitable protection from the hazards involved in your laboratory activities. The following regulations address the role of the teacher's judgment in selecting suitable eye protection:

Occupational Safety and Health Administration OSHA 1910.1450 (Laboratory Standard) Section D(6)

School laboratories should include "protective apparel compatible with the required degree of protection for substances being handled."

As you ponder which type of protective eyewear to purchase, or whether eye protection is needed at all, keep the following suggestions in mind:

- Will you be using heat, glassware or chemicals in the lab? If so, it is a good basic policy to use protective eyewear.
- Chemical splash goggles carrying the D3 rating should be worn whenever hazardous chemicals are used.
- The educational laboratory is a unique environment where each student is often surrounded by other students conducting experiments. Hazards could come from any direction. Protective eyewear should provide sufficient angular coverage.
- Face shields that provide added splash protection coverage should not be worn alone. Always wear the appropriate goggles or safety glasses underneath a face shield.

Conclusion

While ANSI has established many standards for a variety of protective eyewear, it does not provide specific standards for several factors important to the science teacher. Among those are durability and comfort. It is the teacher's responsibility to keep these factors in mind when selecting eyewear. As clearly stated in the *Flinn Scientific Catalog/Reference Manual*, "You, the instructor, should decide what type of eyewear your students must wear in every case." The information and high-quality eye and face protection Flinn provides will help you make an informed, responsible choice.

QUESTIONS? CALL US AT
1-800-452-1261

Chemical **Exposure**

When Are Vapors Harmful to You and Your Students?

Threshold Limit Value (TLV) and Permissible Exposure Limit (PEL) refer to the levels of a chemical above which a person should avoid repeated and prolonged exposure. TLVs and PELs were originally structured to provide guidelines for industrial workers who may be repeatedly exposed to the same chemicals day after day. Science teachers can use these values to provide guidance on which chemicals to use and when to take precautions. TLVs and PELs should be regarded as general standards since different individuals respond differently to exposure. The amount of exposure and the time period of exposure are the critical issues.

The difference between TLVs and PELs is the agencies from which they come. TLVs are developed by the American Conference of Governmental Industrial Hygienists (ACGIH). PELs are developed by the Occupational Safety and Health Administration (OSHA). They both serve the same purpose, and their values are very similar or even identical in many cases. For the remainder of this article, we will refer only to TLVs for simplicity.

TLVs for vapors or gases are reported in units of either parts per million (ppm) or milligrams per cubic meter (mg/m^3) of air. A cubic meter is approximately the size of a small telephone booth. Exposure limits for dust, particulate matter or mist are always reported as milligrams per cubic meter of air.

Many substances have effects that are acute and fast-acting. A ceiling limit has been established for these items. This ceiling suggests that the limit not be exceeded even for an instant. For example, the ceiling TLV for iodine is 0.1 ppm or 1 mg/m^3.

For chemicals that are acute or fast-acting through skin absorption, gloves must be worn; the substances also must be handled in either an operating fume hood or a well-ventilated room.

The threshold of smell of many chemicals is usually below that of the TLV. A strong smell may act as a warning that the TLV is being approached. Since human smelling ability can be impaired by some odors, one should not depend on smell as a reliable indicator of a hazard. Chlorine gas, as an example, has a TLV of 0.5 ppm or 1.5 mg/m3. The odor threshold for chlorine is approximately 0.3 ppm. If you can smell chlorine, you are probably at or near the level of concern.

Biology teachers in particular should note the very low TLV for formaldehyde (0.3 ppm) and make plans to eliminate formaldehyde from their program, use it only under a hood or be sure the room air in their laboratory is being changed (not recirculated) a minimum of 10–12 times per hour. Fortunately, many preserved materials now contain only very small amounts of free formaldehyde.

The best practice is to maintain concentrations of all atmospheric contaminants to the lowest practical levels. Three primary steps will help reduce your exposure to volatile or other airborne chemical substances.

1. **Ventilation.** Ventilation of the school science laboratory should be of paramount importance to the science teacher. Two types of ventilation should be incorporated in the science laboratory. A purge ventilation system (see page 680) should be available to provide a quick air exchange in the laboratory should the level of a hazardous chemical vapor or dust approach the TLV. Also fume hoods should be available and used whenever volatile and hazardous materials are used. A reaction that is performed in a properly operating fume hood will not release any vapors into the laboratory.

2. **Substitution.** Use the TLV table on the following page to substitute a less hazardous chemical for the experiment or activity. For example, if an alcohol is required for an experiment and methyl, ethyl or isopropyl alcohol can be used, the smart choice is to use ethyl alcohol because it has the highest TLV. Another example is melting point determinations. Many teachers have used naphthalene or *para*-dichlorobenzene, both of which have a TLV of 10 ppm. Why not substitute a less hazardous material, such as cetyl alcohol, stearic acid or *t*-octyl phenol?
3. **Microscale.** Scaling down the quantity of material used will reduce the amount that will volatilize into the atmosphere. If a typical class (15 lab groups, 280 m^3 room) performs a lab where sulfur is burned to form sulfur dioxide and the lab is microscaled to use only 0.05 g of sulfur, the average level of sulfur dioxide in the room will probably not exceed 3 mg/m^3, below the TLV of 5.2 mg/m^3. However, if 0.2 g or more are used by each group, the TLV quickly would be exceeded.

TLVs are not well-defined limits between what is safe or unsafe. Rather they should be used as guidelines for the teacher. Most students are in the laboratory for only short periods each week. The teacher's exposure is, of course, much greater. Following these steps greatly will reduce your exposure to hazardous chemicals.

The following page offers a list of common school laboratory chemicals and their TLV values. This is not a comprehensive listing. TLV values are subject to change as new information is developed.

CHEMICAL EXPOSURE continued on next page.

Flinn **Online Chemventory**™

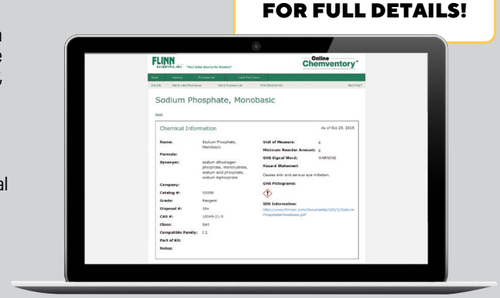
Chemical Inventory Management System

The Flinn Online Chemventory™ is a cloud-based laboratory chemical inventory system that allows multiple users access to the database from multiple locations and multiple devices! Maintaining an accurate laboratory chemical inventory has never been easier, more flexible and more convenient.

The Flinn Online Chemventory™ program features:

- Secure Cloud-Based Service
- Easily Add All Your Flinn Chemicals
- Multiple Users
- Print, Email and Export Your Inventory List
- Customize Your Database
- Link Databases Across Your District
- GHS Hazard Information Included
- Safety Data Sheets for Every Flinn Chemical
- Print Chemical and Solution Labels
- Import Data from Previous Chemventory™ Versions
- Create a Purchase List

SEE PAGES 668–669 FOR FULL DETAILS!



Some Common Chemical TLVs

Substance	TLV (ppm)	TLV (mg/m^3)
Acetic Acid	10	25
Acetic Anhydride[1]	5	21
Acetone	750	1188
Alumina[2]	—	10
Aluminum Metal[2]	—	10
Ammonia	25	17
Ammonium Chloride[2]	—	10
Ammonium Dichromate[2]	—	0.5
n-Amyl Acetate	100	532
Aniline and Homologs[3]	2	7.6
Antimony and Compounds	—	0.5
Arsenic and Soluble Compounds	—	0.01
Barium and Barium Compounds	—	0.5
Barium Sulfate	—	10
Benzene	0.5	1.6
Benzoyl Peroxide	—	5
Bromine and Bromine Water	0.1	0.66
Bromoform	0.5	5.2
Butane	800	1900
2-Butanone	200	590
n-Butyl Alcohol[1,3]	50	152
sec-Butyl Alcohol	100	300
tert-Butyl Alcohol	100	303
Cadmium and Cadmium Compounds[2]	—	0.01
Calcium Carbonate	—	10
Calcium Hydroxide	—	5
Calcium Oxide	—	2
Calcium Sulfate	—	10
Camphor, synthetic	2	12
Carbon Dioxide	5000	9000
Carbon Disulfide[3]	10	31
Cellulose	—	10
Charcoal	—	3.5
Chlorine, gas	0.5	1.5

Substance	TLV (ppm)	TLV (mg/m^3)
Chloroform	10	49
Chromates and Dichromates	—	0.05
Chromium (III) Compounds	—	0.5
Chromium Metal and Insoluble Salts	—	0.5
Cobalt	—	0.02
Copper[2]	—	1
Cyclohexane	300	1030
Cyclohexanol[3]	50	206
Cyclohexanone[3]	25	100
Cyclohexene	300	1010
p-Dichlorobenzene	10	60
Dioxane[3]	25	90
Ether, Ethyl	400	1210
Ethyl Acetate	400	1440
Ethyl Alcohol	1000	1880
Ethylenediamine[3]	10	25
Ethylene Dichloride[3]	10	40
Ethylene Glycol[1]	—	100
Formaldehyde	0.3	0.37
Formic Acid	5	9.4
n-Heptane	400	1640
n-Hexane	50	176
Hydrochloric Acid[1]	5	7.5
Hydrogen Fluoride[1]	3	2.3
Hydrogen Peroxide	1	1.4
Hydrogen Sulfide (gas)	10	14
Hydroquinone	—	2
Iodine[1]	0.1	1
Isoamyl alcohol	100	361
Isopropyl Alcohol	400	983
Lead, Metal and Compounds[2]	—	0.05
Magnesium Oxide[2]	—	10
Manganese[2]	—	0.2
Mercury	—	0.025

Substance	TLV (ppm)	TLV (mg/m^3)
Methyl Alcohol[3]	200	262
Methyl Chloroform	350	1910
Methyl-t-Butyl Ether	40	144
Methyl Ethyl Ketone	200	590
Methyl Isobutyl Ketone	50	205
Methyl Methacrylate	100	410
Naphthalene	10	52
Nicotine[3]	—	0.5
Nitric Acid	2	5.2
Oxalic Acid	—	1
Pentane	600	1770
Phenol[3]	5	19
Phosphorus	0.02	0.1
Phthalic Anhydride[1]	1	6.1
Potassium Hydroxide[1]	—	2
Propane	2500	4508
n-Propyl Alcohol[3]	200	492
Pyridine	5	16
Silver Nitrate (as silver)	—	0.01
Sodium Bisulfite	—	5
Sodium Hydroxide[1]	—	2
Styrene[3]	50	213
Sulfur Dioxide (gas)	2	5.2
Sulfur Hexafluoride	1000	5970
Sulfuric Acid	—	1
Tetrahydrofuran	200	590
Tin (inorganic)	—	2
Titanium Dioxide[2]	—	10
Toluene	50	188
Trichloroethylene	50	269
Turpentine	100	556
Xylenes	100	434
Zinc Chloride[2]	—	1
Zinc Oxide[2]	—	5

A responsible teacher will use a fume hood!

[1]Ceiling TLVs. Chemicals where the TLVs should not be exceeded even for a second. These substances are acute and fast-acting.
[2]TLV for dust or fume.
[3]These chemicals are rapidly absorbed by the skin, eyes and mucous membranes. TLVs should be strictly observed for these substances.

"How Toxic **Is Toxic?**"

Toxicology is defined as the study of the adverse effects of natural and synthetic chemical substances on living organisms. In evaluating the relative toxicity of chemicals, scientists study their mode of action, physical and biological effects and how they can be detected. All chemicals are toxic at some level. Thus every chemical will be toxic under some set of exposure conditions. The reverse, however, is also true—every chemical has some set of exposure conditions in which it is not toxic. The risk or hazard posed by a chemical is further determined by the route and duration of exposure. There are three major routes by which a chemical can enter the body: by ingestion, inhalation and skin absorption. Practicing strict chemical hygiene is thus the most effective way to reduce the hazards and work safely with chemicals.

Acute toxicity, which is defined as the immediate effect of a substance as a result of a single dose, can be measured experimentally. Chronic toxicity, resulting from low doses of a chemical repeated over long periods of time, is more difficult to test and is usually evaluated based on epidemiological evidence. Acute toxicity is determined on the basis of test dosages made on experimental animals under controlled conditions. The most common measure toxicologists use to compare acute toxicity is the LD_{50} value, which stands for "lethal dose, 50%." The LD_{50} value for a chemical is the amount of chemical that can be expected to cause death in one-half (50%) of a group of a particular animal species. Since the amount required to cause death is related to body weight, the LD_{50} value is expressed in milligrams of chemical per kilogram of body weight (mg/kg). A typical LD_{50} statement includes the substance, the route of entry and the animal species as follows: Aniline LD_{50} oral-rat: 250 mg/kg. In plain English, this LD_{50} statement says that 250 mg of aniline for every kilogram body weight of rat, when administered in a single dose by mouth, will cause the death of 50% of the test animals. LD_{50} values are commonly determined for the following routes of exposure: ingestion (oral), skin absorption, subcutaneous or intravenous injection and inhalation.

GHS (Globally Harmonized System of Classification and Labeling of Chemicals) classifies the health hazards due to the acute toxicity of chemicals into four categories:

- Fatal if swallowed: 0–50 mg/kg
- Toxic if swallowed: 0–300 mg/kg
- Harmful if swallowed: 300–2000 mg/kg
- May be harmful if swallowed: > 2000 mg/kg

It should be noted that no LD_{50} data exists for humans. Data from test animals is used to estimate the possible acute toxicity of a chemical on a human being. Toxicity data should therefore be used to evaluate the relative toxicity of various chemicals and which chemicals may require greater precautions when handled. The lower the LD_{50} value, the more toxic the substance. The following chart lists the LD_{50} values for common chemicals. LD_{50} values have not been measured for all chemicals—even some known hazardous chemicals, such as lead compounds, do not have published LD_{50} values.

Substance LD_{50}	per kilogram
Acetaldehyde	661 mg
Acetanilide	800 mg
Acetic Acid	3310 mg
Acetic Anhydride	1780 mg
Acetone	5800 mg
Acetyl Salicylic Acid	200 mg
Adenine	227 mg
Aluminum Chloride	3311 mg
Aluminum Nitrate	3671 mg
Ammonium Chloride	1650 mg
Ammonium Hydroxide	350 mg
Ammonium Molybdate	333 mg
Ammonium Nitrate	2217 mg
Ammonium Persulfate	689 mg
Ammonium Sulfate	2840 mg
Ammonium Thiocyanate	750 mg
n-Amyl Alcohol	5.66 mL
Aniline	250 mg
Aniline Hydrochloride	840 mg
Anthranilic Acid	5410 mg
Antimony Trichloride	525 mg
Arsenic Trioxide	14.6 mg
Barium Acetate	921 mg
Barium Carbonate	418 mg
Barium Chloride (intraperitoneal mouse)	51 mg
Barium Nitrate	355 mg
Benzaldehyde	1300 mg
Benzene	930 mg
Benzoic Acid	1700 mg
Benzyl Alcohol	1230 mg
Bismuth	5000 mg
Bismuth Nitrate	4042 mg
Boric Acid	2660 mg
Brilliant Green	313 mg
Bromine	2600 mg

Substance LD_{50}	per kilogram
Bromobenzene	2383 mg
Bromoform	1147 mg
n-Butyl Alcohol	790 mg
sec-Butyl Alcohol	2193 mg
tert-Butyl Alcohol	2743 mg
Butyric Acid	2000 mg
Cadmium	2330 mg
Cadmium Chloride	88 mg
Cadmium Nitrate	300 mg
Caffeine	192 mg
Calcium Chloride, dihydrate	1000 mg
Calcium Chloride, anhydrous	1000 mg
Calcium Fluoride	4250 mg
Calcium Hypochlorite	850 mg
Calcium Nitrate	3900 mg
Camphor (mouse)	1310 mg
Carbon Disulfide	1200 mg
Cesium Chloride	2600 mg
Cetyl Alcohol	5000 mg
Chloroform	695 mg

Never ingest any laboratory chemical, no matter the LD_{50}.

Chromium(ic) Chloride	1790 mg
Chromium(ic) Nitrate	3250 mg
Chromium Trioxide	80 mg
Cinnamaldehyde	2220 mg
Citric Acid, anhydrous	3000 mg
Cobalt Carbonate	640 mg
Cobalt Chloride	766 mg
Cobalt Nitrate	691 mg
Cobalt Oxide	5000 mg
Cobalt Sulfate	582 mg
Colchicine (mouse)	6 mg

Substance LD_{50}	per kilogram
Copper(I) Chloride	140 mg
Copper(I) Oxide	470 mg
Copper(II) Acetate	710 mg
Copper(II) Carbonate	1350 mg
Copper(II) Chloride	140 mg
Copper(II) Nitrate	940 mg
Copper (II) Sulfate	300 mg
Crystal Violet	420 mg
Cyclohexanol	1400 mg
Cyclohexene	1920 mg
2,6-Di-t-Butyl-4-Methyl Phenol	890 mg
p-Dichlorobenzene	500 mg
2,4-Dichlorophenoxy Acetic Acid	375 mg
1,4 Dioxane	4200 mg
Diphenylamine	1120 mg
Dodecyl Alcohol	12800 mg
Dodecyl Sulfate, Sodium Salt	1300 mg
Eosin Y	2344 mg
Erythrosin B	1840 mg
Ethyl Acetate	5620 mg
Ethyl Ether	1215 mg
Ethylenediamine	1200 mg
Ethylenediaminetetraacetic Acid (mouse)	30 mg
Ethylene Dichloride	670 mg
Ethylene Glycol	4700 mg
Fast Green FCF	2000 mg
Ferrous Ammonium Sulfate	3250 mg
Formaldehyde	100 mg
Formic Acid	1100 mg
Glutaraldehyde	134 mg
Glyoxal	2960 mg
Hexamethylenediamine	750 mg
Hexyl Alcohol	720 mg
Hydroquinone	302 mg
Hydroxylamine Hydrochloride	141 mg

"HOW TOXIC IS TOXIC?" continued on next page.

"How Toxic Is Toxic?", continued

Substance LD_{50}	per kilogram
Indigo Carmine	2000 mg
Indole-3-Butyric Acid	100 mg
Iron(II) Sulfate (mouse)	1520 mg
Iron(III) Chloride	1278 mg
Iron(III) Nitrate	3250 mg
Isobutyl Alcohol	2460 mg
Isopentyl Alcohol	1300 mg
Isopropyl Alcohol	5045 mg
Isoraleric Acid	1850 mg
Kerosene (rabbit)	2835 mg
Lactic Acid	3543 mg
Lead Acetate	4665 mg
Lithium Carbonate	525 mg
Lithium Chloride	526 mg
Lithium Sulfate (anhydrous salt)	613 mg
Magnesium Nitrate	5440 mg
Malachite Green Oxalate	275 mg
Maleic Acid	708 mg
Malonic Acid	1310 mg
Manganese(II) Chloride	1484 mg
Menthol	3180 mg
Methyl Alcohol	5628 mg
Methyl-t-Butyl Ether	4000 mg
Methyl Ethyl Ketone	2737 mg
Methyl Isobutyl Ketone	2080 mg
Methyl Orange	60 mg
Methyl Salicylate	887 mg
Methyl Violet 2B	413 mg
Methylene Blue	1180 mg
Methylene Chloride	1600 mg
Naphthalene	490 mg
Naphthalene Acetic Acid	1000 mg
1-Naphthol	1870 mg
Nickel Ammonium Sulfate	400 mg
Nickel Chloride	105 mg
Nickel Nitrate	1620 mg
Nicotine	50 mg
o-Nitrobenzaldehyde	600 mg
meta-Nitrophenol	328 mg
para-Nitrophenol	202 mg
1-Octanol (mouse)	1790 mg
4-(t-Octyl) Phenol	3210 mg
Orcinol (guinea pig)	600 mg
Oxalic Acid	375 mg
Pentane	400 mg
Peppermint Oil	2426 mg
Perchloroethylene	2629 mg
1,10-Phenanthroline	132 mg
Phenol	317 mg
Phenyl Salicylate	3000 mg
Phenyl Thiocarbamide (mouse)	10 mg
Phosphoric Acid	1530 mg
Phosphorous Pentoxide (inhalation, LD_{50})	1217 mg/m^3
Phthalic Anhydride	4020 mg
Potassium Acetate	3250 mg
Potassium Bisulfate	2340 mg
Potassium Bromate	157 mg
Potassium Bromide	3070 mg
Potassium Carbonate	1870 mg
Potassium Chlorate	400 mg
Potassium Chloride	2600 mg

Substance LD_{50}	per kilogram
Potassium Chromate (mouse)	180 mg
Potassium Cyanide	5 mg
Potassium Dichromate	25 mg
Potassium Ferricyanide	1600 mg
Potassium Ferrocyanide	6400 mg
Potassium Fluoride	245 mg
Potassium Hydroxide	273 mg
Potassium Iodate	531 mg
Potassium Nitrate	3750 mg
Potassium Nitrite	200 mg
Potassium Permanganate	1090 mg
Potassium Persulfate	802 mg
Potassium Thiocyanate	854 mg
Propionic Acid	2600 mg
n-Propyl Alcohol	1870 mg
Pyridine	891 mg
Pyrogallol (mouse)	300 mg
Resorcinol	301 mg
Rhodamine B (mouse)	887 mg
Salicylic Acid (mouse)	480 mg
Sebacoyl Chloride	400 mg
Silicon	3160 mg
Silver Nitrate	1173 mg
Silver Oxide	2820 mg
Soda Lime	3530 mg
Sodium Acetate	3530 mg
Sodium Arsenite	41 mg
Sodium Benzoate	4070 mg
Sodium Bicarbonate	4220 mg
Sodium Bismuthate	420 mg
Sodium Bisulfite	2000 mg
Sodium Borate	2660 mg
Sodium Bromate	300 mg
Sodium Bromide	3500 mg
Sodium Carbonate	4090 mg
Sodium Chlorate	1200 mg
Sodium Chloride	3000 mg
Sodium Chromate, tetrahydrate	52 mg
Sodium Chromate, anhydrous	136 mg
Sodium Dichromate	52 mg
Sodium Fluoride (mouse)	57 mg

Substance LD_{50}	per kilogram
Sodium Hexametaphosphate (mouse)	4320 mg
Sodium Iodide	4340 mg
Sodium Metabisulfite	1131 mg
Sodium Metasilicate	1153 mg
Sodium Nitrate	1267 mg
Sodium Nitrite	180 mg
Sodium Oxalate (mouse)	5094 mg
Sodium Perborate	1200 mg
Sodium Salicylate	930 mg
Sodium Sulfide (anhydrous salt)	208 mg
Sodium Sulfite	3560 mg
Sodium Thiocyanate	764 mg
Streptomycin Sulfate	430 mg
Strontium Chloride (anhydrous salt)	2250 mg
Strontium Nitrate	2750 mg
Styrene, Monomer	2650 mg
Succinic Acid	2260 mg
Sulfamic Acid	3160 mg
Sulfanilamide	3900 mg
5-Sulfosalicylic Acid	2450 mg
Sulfuric Acid	2140 mg

To put toxicity into perspective, compare the LD_{50} to that of sodium chloride (3000 mg).

Tannic Acid	2260 mg
Tetrahydrofuran	1650 mg
Thioacetamide	301 mg
Thiourea	125 mg
Thymol	980 mg
Tin(II) Chloride	700 mg
Toluene	636 mg
Trichloroethylene	4920 mg
Triethanolamine	4.92 mL
Urethane	1809 mg
Xylenes	4300 mg
Zinc Acetate	794 mg
Zinc Chloride	350 mg
Zinc Nitrate	1190 mg
Zinc Sulfate	1260 mg

Safer Storage

Provide extra safety for the storage of severe poisons. Chemicals that have an LD_{50} of less than 300 mg/kg may be described as fatal or toxic if swallowed. These should be stored in a separate and secure storage cabinet to protect against theft, vandalism, or fire.

The Flinn/SciMatCo® Poison Cabinet is compact and will fit into an existing storage cabinet or shelf.

Severe poisons must be locked up. The Flinn/SciMatCo® Poison Cabinet is a "must" safety aid for any high school chemical storage area.

Catalog No.	Description	Price/Each
SE6080	Flinn/SciMatCo® Wooden Poison Cabinet	$580.05

See page 644 for more information.

Flammable **Liquid Safety**

Safety Tips for Using Flammable Liquids in School Laboratories

Introduction

The use of flammable liquids is an important part of most chemical laboratories. Understanding the properties and hazards of these materials is an important first step for the safe purchase, storage, use and disposal of flammable liquids.

Safety Precautions

All flammable liquids found in school environments are also organic compounds. Their principal hazard is flammability. Many are also slightly toxic by inhalation and are body tissue irritants. Mild headaches or dizziness may be a symptom of overexposure to an organic vapor. Good ventilation is highly recommended whenever volatile organic compounds are used. Specific hazards for common organic solvents are presented in this review. Always wear chemical splash goggles, chemical-resistant gloves and chemical-resistant apron whenever using flammable liquids. Consult current Safety Data Sheets for specific safety, handling and disposal information.

Purchase

- Before purchasing any organic liquid, ask the following questions:
  - — Do I understand the hazards of this material?
  - — How often is this chemical used in a school setting?
  - — What is the educational value of this chemical?
  - — Have I used this chemical before?
  - — Is my lab equipped for the safe use and storage of this chemical?

  If these questions cannot be answered positively, please reconsider purchasing the chemical.
- Organic compounds are not easy to dispose of and frequently require costly disposal methods. Purchase only what is required for 1–2 years' usage.
- Purchase smaller-size bottles of flammable liquids whenever possible to keep them fresh and to make storage and handling easier. It is easier to handle a 100- or 500-mL bottle than a 1- or 4-L jug. Smaller bottles also contain less liquid that can spill in the event of an accident and thus will add less fuel to a potential fire.
- Always purchase flammable liquids in plastic or PVC-coated glass bottles. PVC-coated bottles will not shatter and spill material when dropped.

Storage

- Store all flammable liquids, solids and gases in a dedicated flammables cabinet. The best flammables cabinets are built using high-density wood. Metal is a heat conductor while wood is an insulator. Applying intense heat to a metal flammables cabinet may cause the door to warp and release flammable liquids and vapors into the fire. A wooden flammables cabinet insulates the chemicals inside the cabinet and will withstand a fire better than a metal cabinet. Wooden flammable cabinets have been reviewed and approved by the major standard-setting organizations, including OSHA and NFPA, and by many major city fire departments.
- Flammables storage cabinets should be located in a locked chemical storeroom to prevent theft. The cabinets should also be secured with a lock.
- Within the flammables cabinet, all the materials should be stored using the Flinn Scientific Chemical Storage Pattern.
- A chemical storeroom that contains flammable materials should be equipped with an ABC fire extinguisher, fire blanket and smoke detector.
- The chemical storeroom should also be equipped with a small, corrosive-resistant exhaust system.

Store all flammable liquids in a dedicated flammables cabinet.

Flinn Scientific recommends a fan that will provide four air changes per hour. The fan should be placed near the ceiling of the storeroom. Since organic vapors are heavier than air, the exhaust system must draw vapors up from the floor. Use a galvanized sheet metal duct to draw air from the floor to the exhaust fan near the ceiling (see page 680).

- If a flammables cabinet is not available, store all flammable liquids in Flinn *Saf-Stor*™ cans (see page 653). This will provide good secondary containment and protection during fires.
- Never store flammable or combustible materials near strong oxidizing agents. As these materials react with one another, heat is evolved and a fire can occur. Use the Flinn Scientific Chemical Storage Pattern to prevent storage accidents (see pages 726–730).
- Diethyl ether may form explosive peroxides over the course of 1–2 years. Buy and store only small quantities of this material.
- Never store flammable liquids in a household refrigerator or freezer. Vapors can build up inside the refrigerator, and a spark from the compressor, thermostat, lightbulb or electrical switch can ignite the vapors. Explosion-proof refrigerators can be purchased, but they cost 3–4 times more than household refrigerators.
- Some alcohols also will form peroxides upon standing. These peroxides can be explosive if they are allowed to accumulate or are concentrated. Do not distill these materials. Consult the *Flinn Scientific Catalog/Reference Manual* or SDSs to determine storage recommendations for specific alcohols.

Transporting

- Secondary containment is critical in preventing major spills or accidents when transporting flammable liquids. Make sure all flammable and combustible liquids are in unbreakable plastic or PVC-coated glass bottles, or transport them in unbreakable bottle carriers.
- Always carry large flammable liquid bottles with one hand underneath the bottle and the other hand around the neck of the bottle. This keeps the bottle closer to your body and decreases the risk of hitting a sharp object like a desk corner.
- If a cart is used to transport hazardous chemicals, place compatible chemicals inside an unbreakable secondary containment vessel, such as a plastic tote. The cart should be equipped with guardrails to prevent plastic totes or bottles from sliding off.
- If hazardous chemicals are moved from one floor to another, use an elevator if possible. Only the teacher transporting the chemicals should be on the elevator. Although elevator accidents are rare, should a dangerous material be released in an elevator while passengers are trapped inside, the results could be catastrophic.

Using and Dispensing Flammable Liquids

- If volatile organic solvents are going to be used, the lab must be well ventilated or have a working purge fan to ventilate the lab. The laboratory should also be equipped with one or two ABC dry-chemical fire extinguishers and fire blankets in addition to the other normal safety equipment (e.g., safety eyewash, safety shower).
- Always review SDSs before using any hazardous materials in the laboratory.
- Flammable liquids should not be mixed with strong oxidizing agents. As the organic material is oxidized, heat is evolved and may ignite the material, resulting in a fire.

FLAMMABLE LIQUID SAFETY continued on next page.

Flammable Liquid Safety, continued

- Extreme care must be taken when using flammable liquids around any heat source, flames or electrical equipment. Laboratory equipment (e.g., stirrers, meters) are designed to be sparkproof, but limiting vapors is always a good safety precaution.
- Organic vapors are heavier than air and will quickly travel along a lab bench or floor to an ignition source. Never use flammable liquids around any ignition source. Try to minimize the amount of volatile liquids used and be aware that organic vapors can travel great distances.
- Flammable liquids are very volatile. Dispense them in an operating fume hood.
- Use lab mats and/or plastic trays when dispensing organic solvents to contain spills and drips.
- Students should dispense flammable liquids from smaller bottles to limit spills and fumes. Do not allow students to dispense flammable liquids from containers larger than 1 liter. Larger volume containers increase the possibility of contamination and also increase the amount of fuel that will be available in case of a fire.
- During lab, dispense the flammable liquid from a central dispensing location and have students bring a graduated cylinder or test tube to the dispensing area. This will help minimize spills and accidents as well as limit the amount of flammable liquid being brought back to the lab bench.

Dispense flammable liquids in an operating fume hood.

- Instruct students to remove from the bottle only the amount of flammable liquid needed for the experiment. Never add chemicals back to reagent bottles.
- Have spill clean-up materials readily available whenever flammable liquids are used. If a spill occurs, immediately restrict unprotected personnel from the area, remove all ignition sources and ventilate the area. If the spill is too large to contain, the vapors are overpowering or ignition sources cannot be completely removed, immediately evacuate the school and call the fire department. If the spill is small, contain the spill with sand or an absorbent material. Depending on the spill material and the amount, allow the spilled material to evaporate off the sand or absorbent material in a fume hood or deposit it in a sealed bag or container.
- Absorbent spill pillows are great absorbents for most organic spills. The pillows quickly absorb 10–20 times their weight, making disposal very easy (see page 678).

Personal Protective Equipment and Safety Aids

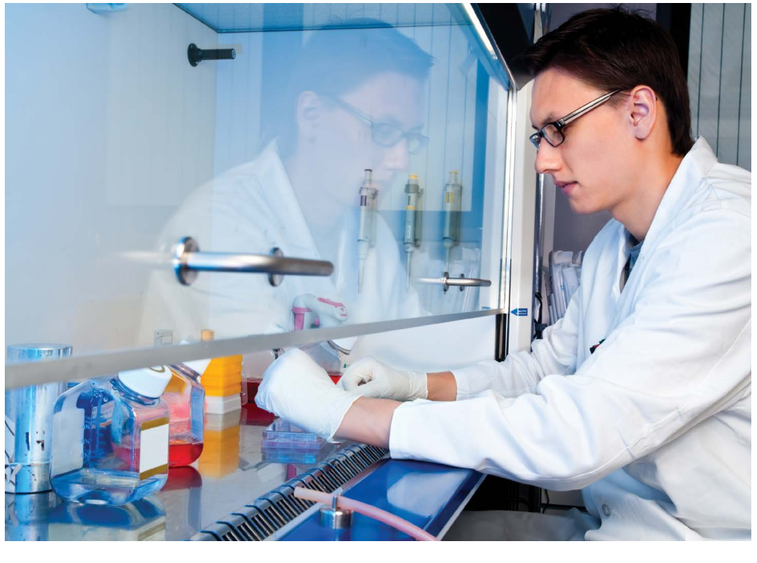
- Consult the SDSs for the specific personal protective equipment required and other safety precautions for the flammable material being used.
- Neoprene rubber gloves are recommended when handling organic solvents. Plastic or vinyl gloves will provide some protection against the occasional splash, small spill and splatter that may occur when using or dispensing solvents.
- Operating eyewashes must be available in any classroom or laboratory where chemicals are used. Approved eyewashes must treat both eyes and provide a stream of clean, potable water for at least 15 minutes.
- Chemical splash goggles must be worn anytime flammable liquids are used. Safety glasses are not adequate protection.
- During demonstrations, it is very important that students wear chemical splash goggles anytime flammable liquids are used. The possibility of an explosion or fire always exists, and both students and teachers must be protected. If safety goggles are not available, use a heavy-duty safety shield to protect your students.

First Aid

- Always seek professional medical attention upon exposure to any hazardous chemical, especially volatile organic solvents. For most organic solvents, the major hazards are flammability and inhalation. If there is a spill or accident, immediately remove any flames, heat or electrical equipment from the area and begin to ventilate the space.
- If an organic liquid is splashed in the eyes, use an eyewash to irrigate the eyes with fresh, potable water for at least 15 minutes. Make sure the eyelids are held open to properly irrigate them. Ask the victim to look up, down and sideways to better reach all parts of the eye. After using the eyewash, immediately seek professional medical help.
- If a flammable liquid is splashed onto bare skin, rinse the area with cool water for at least 15 minutes. Many organic solvents will "dry out" the skin and cause minor dermatitis. If the liquid causes burns or other skin irritations, seek medical help immediately.
- If a large amount of flammable liquid is splashed onto clothing, consider removing the clothing immediately and placing the clothing in a fume hood or outdoors. If flammable liquid splashes onto your skin and clothing, remove clothing and then begin rinsing the affected areas with water (using a safety shower is ideal).
- If an organic liquid is ingested, please consult the SDS and immediately call the poison control center (1-800-222-1222) or local hospital emergency room. Follow their directions and seek medical attention as soon as possible. For most organic solvents, the goal is to trap the chemical in the stomach and prevent further injury caused by vomiting. Activated charcoal is sometimes given to help trap the chemical. Do not give the victim anything to drink or induce vomiting unless instructed by a medical professional.

Disposal

- Consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes. For small amounts of most volatile organic liquids, Flinn Suggested Disposal Method #18a, evaporation in an operating fume hood, can be used. For larger amounts, a professional chemical waste disposal firm will have to be used.
- Waste crocks or "slop" buckets are used in many schools for liquid laboratory wastes. Organic wastes should be kept separate from aqueous wastes to prevent any accidental reactions. For organic waste containers, it is best to separate halogenated organic solvents (e.g., methylene chloride) from other organic solvents (e.g., ethyl alcohol) for disposal. Sometimes volatile organic solvents can be evaporated in a fume hood from the organic waste container. Be sure to label all waste containers with their approximate contents. Dispose of all waste solutions as soon as possible.



Acid **Safety**

Safety Tips for Using Acids in School Labs

Introduction

The use of acids is an important component of most chemical laboratories. Understanding the properties and hazards of acids is an important first step for the safe purchase, storage, use and disposal of acids.

Safety Precautions

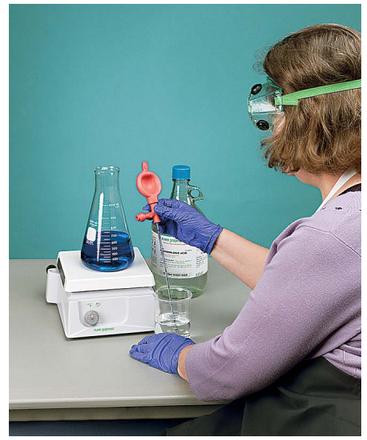
Concentrated acids are strongly corrosive to all body tissue, especially eyes and skin. Concentrated acids are highly toxic due to their extreme corrosiveness. Hydrochloric and acetic acids are also toxic by inhalation. Other hazards are presented in this review. Always wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron whenever using concentrated acids or acid solutions.

Purchase

- Purchase dilute acids whenever possible. Dilute acid solutions are safer and easier to handle, use and store than concentrated acids. They also will save valuable prep time.
- Purchase small quantities of acids to help keep your acid fresh and make storage and handling safer and easier. It is easier to clean up a 100-mL acid spill than a 2.5-L one.
- Always purchase concentrated acids in PVC-coated glass bottles, which will not shatter and spill acid when dropped. The PVC creates a plastic envelope around the bottle that greatly reduces spills and breakage. The PVC coating may discolor over time, especially when exposed to hydrochloric acid fumes. This discoloration does not affect the PVC coating or the quality of the acid inside the bottle.

Storage

- Store all acids in a dedicated corrosives or acid cabinet. The best acid cabinets are built with wood because metal cabinets will quickly corrode from acid fumes. Wood cabinets will provide years of safe and durable acid storage. The cabinet should be located in a locked chemical storeroom. If not, the cabinet must be secured with a lock.
- Storing acids and bases together in one corrosives cabinet is acceptable if they are physically separated on different shelves or isolated from one another. Bottles may become covered with ammonium chloride from hydrochloric acid and ammonia fumes. The cabinet and bottles should be washed with TSP (trisodium phosphate) or other strong cleaners to remove the white film.
- Label all prepared acid solutions before storing them with at least the name of the acid, concentration, hazard warning or how the acid can hurt you and date prepared.
- Always keep the appropriate color-coded acid bottle cap on the concentrated acid bottle. Never use these caps on other bottles. Color-coded bottle caps provide an extra safety measure to identify concentrated acids if the label gets removed or destroyed. If an acid bottle cap becomes cracked or discolored, always replace the cap with the proper color-coded cap. The following colors are used on all concentrated reagent bottles sold in the United States.
  - Acetic Acid — Brown
  - Phosphoric Acid — White
  - Hydrochloric Acid — Blue
  - Sulfuric Acid — Yellow
  - Nitric Acid — Red
  - Ammonium Hydroxide — Green
- Concentrated hydrochloric acid fumes continuously so it cannot be stored without releasing hydrochloric acid fumes. These fumes are responsible for most of the corrosion damage in your chemical storeroom. Storing hydrochloric acid in a wood acid cabinet is a must. Hydrochloric acid fumes will quickly corrode metal cabinets.
- Nitric acid is a strong oxidizing agent. Concentrated nitric acid must be stored in a separate liquid-tight compartment within an acid cabinet. If nitric acid is mixed with a flammable organic compound, such as acetic acid, the heat from the oxidation and neutralization reactions is enough to ignite the flammable material. Nitric acid also slowly destroys its red plastic bottle cap. Always replace it with a new red cap. Nitric acid may turn yellow over time because of the release of nitrogen dioxide on exposure to light. The yellow color does not affect the product's usefulness in the school laboratory.
- Glacial acetic acid is a flammable liquid. It should be stored in an acid cabinet but in a location isolated from possible contact with nitric acid. Glacial acetic acid freezes at 16.6 °C; the material may crystallize in a cool storeroom. If this occurs, allow the bottle to warm up to ambient (25 °C) temperature.
- Concentrated sulfuric acid is a strong dehydrating agent. Because of its strong ability to remove



water, it reacts violently with many organic materials, such as sugar, wood and paper. If sulfuric acid has turned brown, it has probably been contaminated with an organic material, and its purity should be in question.
- Concentrated phosphoric acid has a melting point close to ambient temperature and may also crystallize in a cool storeroom. Phosphoric acid is hygroscopic and will absorb water over time. Keep it tightly sealed.

Transporting

- Secondary containment is critical to prevent major spills or accidents when transporting acids. Use PVC-coated acid bottles or unbreakable bottle carriers.
- A good habit is to check the acid bottle for cracks before touching or picking it up. Also check for spilled acid on the handle or bottle.
- Always carry 2.5-L acid bottles with one hand underneath the bottle and the other hand around the neck or finger hole. This keeps it closer to your body and decreases the risk of hitting a sharp object, like a desk corner, and breaking the bottle.
- Plastic or rubber safety bottle carriers should be used whenever acids are transported from one laboratory to another or from the storeroom to a laboratory.

ACID SAFETY continued on next page.

Properties of Acids

Acid	Formula	F.W. g/mol	Specific Gravity	Concentrated Acid	
				wt% Acid	Molarity
Acetic	$HC_2H_3O_2$	60.05	1.05	99.8	17.4
Hydrochloric	HCl	36.46	1.19	37.2	12.1
Nitric	HNO_3	63.02	1.42	69.5	15.8
Phosphoric	H_3PO_4	98.00	1.70	86	14.8
Sulfuric	H_2SO_4	98.08	1.84	96	18.0

Acid Safety, continued

- If a cart is used to transport hazardous chemicals, including acids, place compatible chemicals inside an unbreakable secondary containment vessel, such as a plastic tote. The cart should be equipped with guardrails to prevent plastic totes or bottles from sliding off the cart.
- If hazardous chemicals are moved from one floor to another, use an elevator if possible. Only the teacher transporting the chemicals should be on the elevator. Although elevator accidents are rare, should a dangerous material be released in an elevator while passengers are trapped inside, the results could be catastrophic.

Preparation of Acid Solutions

See page 713.

To Prepare a Solution

1. Add the appropriate amount of acid to about ⅔ of the required amount of distilled or deionized water.
2. Always add acid to water! Never add water to concentrated acids. The acid may splatter and generate acidic steam.
3. Always use borosilicate (e.g., Pyrex®) glassware.
4. Stir to mix the solution.
5. Once the solution has cooled to ambient temperature, dilute the solution to the proper volume with water.
6. Use a volumetric flask for accuracy, if needed.
7. When diluting sulfuric acid, place the borosilicate beaker or flask in an ice bath. The heat of dilution of sulfuric acid is very high and may melt plastic containers or crack nonborosilicate glassware.

Using and Dispensing Acids

- Always review the Safety Data Sheet (SDS) before using any hazardous material in the laboratory.
- Students should dispense acids from smaller bottles to limit spills and fumes.
- Use lab mats and or plastic trays when dispensing acids to contain acid spills and drips.
- Dispense acids, especially hydrochloric, nitric and acetic acids, in an operating fume hood.
- During lab, set the acid bottle in a central dispensing location and have students bring a graduated cylinder or test tube to the dispensing area. This will help minimize spills and accidents and will limit the amount of acid that is brought back to the lab bench.
- Instruct students to remove from the bottle only the amount of acid needed for the experiment. Chemicals are never added back to the reagent bottle.
- Have acid spill clean-up materials readily available whenever acids are used.
- Attach a test tube to the reagent bottle to store the pipet for dispensing an acid.
- Acids are corrosive and will eat through most fabrics, resulting in small holes in clothing. This process does not occur instantly, but rather over several hours, and may not become apparent until the clothes are washed. Always wear a chemical-resistant apron or laboratory coat when working with acids.

Personal Protection Equipment and Safety Aids

- Nitrile rubber gloves are acid-resistant and are the best choice to use when handling concentrated acids. However, any plastic or vinyl glove will provide some protection against the occasional splash, small spill and splatter that may occur when using or dispensing acids.
- Operating eyewashes must be available in any classroom or laboratory where acids or acid solutions are used. An approved eyewash must treat both eyes and provide clean potable water for at least 15–20 minutes.
- Chemical splash goggles must be worn anytime acids or acid solutions are used. Safety glasses are not adequate protection.
- Good ventilation should be available whenever hydrochloric, nitric or acetic acid will be used in the lab.
- Spill control materials (e.g., sand, absorbent and neutralizer) must be available whenever acids or acid solutions are used.

First Aid

- Always seek professional medical attention upon exposure to any hazardous chemical, especially concentrated acids.
- The best first aid for any chemical exposure to body tissue or eyes is immediate dilution with water.
- If an acid is splashed in the eyes, use an eyewash to irrigate the eyes for at least 15–20 minutes. Make sure the eyelids are held open to properly irrigate them. Ask the victim to look up, down and sideways to better reach all parts of the eye.

Always add acid to water…

- If an acid is splashed onto bare skin, rinse with water for at least 15–20 minutes.
- If an acid is splashed onto clothing, remove the clothing immediately before the acid soaks through the clothing and reacts with the skin. If an acid splashes onto your skin and clothing, immediately begin rinsing the affected skin with water (a safety shower is ideal) and then begin to remove affected clothing. Modesty must take a back seat to potential chemical burns that can occur.
- If acid is ingested, the primary goal is to dilute the acid in the stomach and prevent further injury caused by vomiting. If the victim is conscious, immediately have the victim rinse their mouth out with water. Have the victim drink one or two cups of water or milk. Gastric antacids, such as milk of magnesia or aluminum hydroxide, can also be given. Do not induce vomiting, do not try to neutralize the acid with a strong base, and do not give the victim any sodium bicarbonate or any carbonated drinks. Call poison control center (1-800-222-1222) or hospital emergency room and follow their directions.

Always dilute and neutralize acids before disposal.

Disposal

- Always dilute and neutralize all acids before disposal.
- See Flinn Suggested Disposal Methods #24a and #24b in the *Flinn Scientific Catalog/Reference Manual* for detailed disposal procedures and warnings.

Seven-Step Plan to Clean Up
Your Chemical Storage Area

For years you have wanted to clean up and organize your chemical storage area. But it's such a huge job, where do you begin? Our seven-step plan will give you the direction and guidance you need to get this job done safely, quickly and efficiently.

Before we begin, some ground rules need to be established:

- Teachers cleaning up the chemical storage area should do so in teams. This work should never be done alone. Students should never be involved.
- Teachers doing this work should be from the school where the work is being done. The best time to do this type of work is immediately after school gets out in the spring.
- Teachers should be hired on an extended contract during the summer months to undertake this project. For an average-size school of 1,000 students, it will take a team of 3–4 teachers two weeks to clean up the chemical storage area.
- Teachers on an extended contract also should be covered by the school's insurance policy in the unlikely event of an injury.

It's very important that the teachers be paid for the work they are about to undertake. This problem of old chemicals may have existed long before the teachers started working at the school. Compensation from the school district is only fair.

STEP 1: Take an Inventory

The most important step in cleaning up a chemical storage area is taking an accurate and complete inventory of every chemical in every chemical storage area, laboratory and classroom. Without a complete inventory, you will not be able to proceed to step 2. Don't forget to check closets and drawers. Details on how to take an inventory can be found on pages 721–725 of this *Flinn Scientific Catalog/Reference Manual*. Please read these instructions carefully!

Critical information will be needed from your inventory. Most particularly, you will want to know: (1) the name of the chemical, (2) its shelf location and (3) the approximate amount of chemical estimated to be in each container.

The shelf location of each chemical is important because it is likely that the same chemical will be found in several locations. Shelf location information will help you track down and consolidate these chemicals.

STEP 2: What Chemicals Do You Really Use?

It is fair to say that 40% of the chemicals you have in your chemical storage area have not been used in the last five years and probably won't be used in the next five years. Now is the time to decide which chemicals are really used. Once the inventory is complete, review your laboratory manuals, textbooks, demonstrations and science fair projects to decide which chemicals are used and which chemicals are not.

As you review your inventory, you may discover an excessive amount of some chemicals. Calculate what quantities of these chemicals you use every year and then decide to keep no more than a two- to five-year supply. Determining how much chemical to keep will be influenced by two factors: the chemical shelf life and the hazardous nature of the chemical. The poorer the shelf life or the more hazardous the chemical, the less you will want to keep on hand. Shelf life and hazard information may be found in the *Flinn Scientific Catalog/Reference Manual* under each chemical listing.

If the chemical is not hazardous and has an indefinite shelf life, keep a four- to five-year supply. However, if the chemical is hazardous and the shelf life is poor, keep only a one-year supply on hand. Look carefully at each bottle, try to determine which bottle looks the freshest or has the best shelf life and only keep the amount you really think you need. Let the shelf life and chemical hazard information found in the *Flinn Scientific Catalog/Reference Manual* guide the way.

STEP 3: Organizing Your Chemical Storage Area

You now know which chemicals you use, which chemicals you want to keep and which chemicals you don't want. Let's now physically move all of the chemicals in the chemical storage area (and anywhere else you found chemicals) out into the laboratory area and onto the lab benches. (The laboratory next to the chemical storage area works best.) The right side of the laboratory will become an area for chemicals you either no longer use or have in excessive amounts and would like to dispose of.

The left side of the laboratory will be chemicals you want to keep. It's important that only authorized people working on this project be allowed to enter this room. Administrators, maintenance people and others must not be allowed into this laboratory area unless they are accompanied by one of the teachers involved in the clean-up project. This laboratory should be locked when not in use. If you discover chemicals that you feel uncomfortable moving or handling, please call Flinn Scientific for further advice.

STEP 4: Bag and Can Dangerous Chemicals or Practice "Devil Control"

There are certain chemicals found on school premises that Flinn Scientific considers to be "devils." A "devil" is any chemical that has a severe hazard alert. Severely poisonous, severely toxic, severely flammable, severely corrosive, strong oxidizer, carcinogen or strong stench are all characteristics that may qualify a chemical as a "devil."

To practice "devil control," purchase some clear, heavyweight plastic bags with twist ties, cat litter and a selection of clean (empty) quart and gallon paint cans.

The first step in practicing "devil control" is to place each chemical container considered to be a "devil" into a clear plastic bag. Secure the bag with a twist tie. Should the bottle break, the spill will be contained in the plastic bag.

Once the chemical bottle is in the plastic bag, spread a thin layer of cat litter in the bottom of a paint can, place the sealed bag with the chemical container into the paint can and fill the remaining portion of the can with cat litter. Place the lid on the paint can and label the can clearly with the chemical

SEVEN-STEP PLAN continued on next page.

name, chemical formula and hazard risk. Your "devil" chemical is now well protected! The metal paint can may be dropped, kicked or even involved in a fire and the chemical container inside will not break. Should a leak occur, the cat litter will absorb the chemical and the spill will be contained inside the can.

Most "devils" may only be used once or twice during the school year, but you need to properly protect and store these chemicals when they are not being used. Bags and cans are a very effective yet inexpensive way to protect these "devil" chemicals.

STEP 5: Improve the Chemical Storage Area Facility

Now that the chemicals have been moved out of the chemical storage area and into the laboratory, you have an opportunity to make some improvements to the chemical storage area. First of all, give the room a good cleaning. Make sure the shelves are firmly attached to the wall and in good condition. If the shelves are not in good condition, some type of repair or replacement should be made. Check the shelf clips carefully to make sure they are in good condition and not corroded. Better yet, replace the "adjustable" shelves with permanent shelves that will never collapse. Put "lips" on the shelves to prevent bottle roll-off. Inspect the rest of the chemical storage area. Do any other improvements need to be made?

STEP 6: Organize Chemicals by Compatible Families

Now that the "devil" chemicals have been bagged and canned and the storage area has been improved, it's time to return the chemicals you want to keep back into the chemical storage area. Before these chemicals are moved back in, you must decide how they are to be stored and organized. In the past, they may have been stored alphabetically. This is wrong! Chemicals should be stored and organized by compatible chemical families. Pages 726–730 of this *Flinn Scientific Catalog/Reference Manual* describe how to properly store laboratory chemicals. Thousands of schools across the United States have adopted the Flinn Suggested Chemical Storage Patterns for the storage of their laboratory chemicals. Many states and insurance companies recommend the Flinn Suggested Chemical Storage Patterns as the preferred method of chemical storage.

First, separate your chemicals into compatible families by dividing the chemicals into inorganic and organic families then subdividing them further into their unique compatible chemical families. For instance, oxidizers are broken into five different families. Nitrates are stored in Inorganic #3, except ammonium nitrate, which is isolated. Chromates and permanganates are stored in Inorganic #8. Chlorates and perchlorates are stored in Inorganic #6, and nitric acid is stored separately in a dedicated acid cabinet.

Before the chemicals are moved back into the chemical storage area, it is very helpful to label each chemical bottle with the appropriate compatible chemical family storage number. It is also helpful to label each shelf with the compatible family number. Labeling both the chemical shelving and the chemical bottles with the appropriate Flinn compatible chemical family number will allow you to easily locate and return any chemical to its appropriate storage location. Without this labeling, you'll soon find your chemical storage area in disarray. You make your own bottle and shelf labels or purchase preprinted labels from Flinn Scientific, Inc. (All Flinn chemicals are already labeled with this information.)

STEP 7: Chemical Disposal—Your Options

Now that your chemicals have been properly bagged, canned, labeled and placed back into the chemical storage area using Flinn's Suggested Compatible Family Shelf Storage Patterns, your task is now complete...almost.

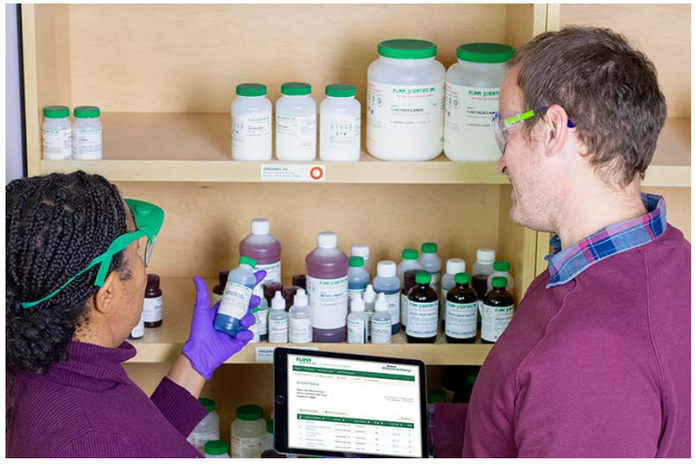
As you walk out of the chemical storage area feeling good about what you have accomplished, you soon realize you still have all of those chemicals that need to be disposed of. What are your options for chemical disposal? Flinn has devoted 30 pages in this catalog/reference manual to disposal procedures. First read about your options on pages 731–732, and if you want to dispose of small quantities of chemicals, refer to the disposal procedures found on pages 736–753.

We hope our seven-step plan to clean up your chemical storage area has given you the direction and courage needed to improve the safety profile of your school. It's no small task to clean up a chemical storage area, but with a well-defined plan and the support of your school administration, this job can be done.

Good luck! If you have any questions, please feel free to call us. We're here to help!

FREE! Seven-Step Plan to Clean Up the Chemical Storage Area Video

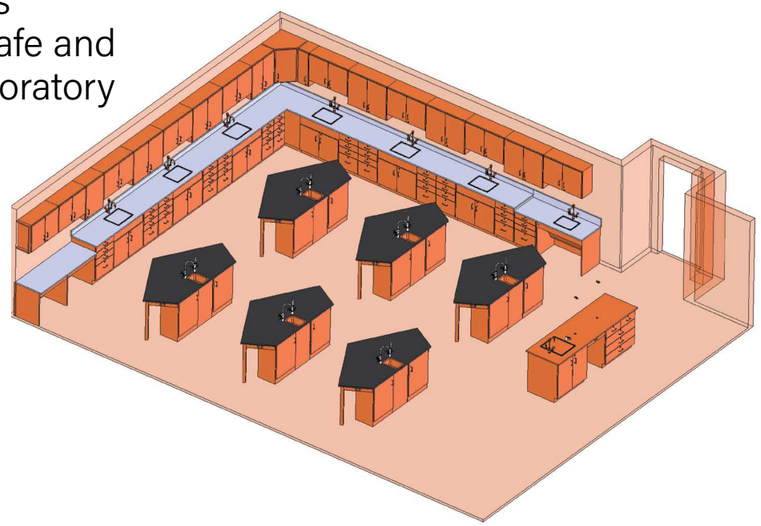
Flinn Scientific has created a free online video series describing a seven-step plan to help you clean up your chemical storage area. Each video chapter covers one step of the process, from taking a chemical inventory to storing chemicals safely and understanding chemical treatment or disposal options. By following the steps in each video, you will gain the confidence of knowing your chemical storeroom is safe and organized. We also provide suggestions on how to convince your administration to allocate the time and money necessary for you to take a chemical inventory and clean up the chemical storeroom.



VISIT FLINNSCI.COM TO VIEW TODAY!

Chemistry **Laboratory Design**

45 Ideas, Tips and Hints to Help You Design a Safe and Efficient Chemistry Laboratory



The overall safety profile of your school would be greatly improved if the chemistry laboratory, preparation room and chemical stores area were properly designed in the first place. Many schools are now in the process of renovating or building new chemistry labs. As the chemistry teacher who will work in these labs, you want them properly designed. Where are you to learn about chemistry lab designs that work? Who knows which designs are best for your specific laboratory needs? The answer is simple—Flinn Scientific!

Typically a local architect is hired to design a new school or science lab. It's assumed that the architect will ask the right questions and will have all the correct answers. Unfortunately, the architect may have little or no experience designing a chemistry lab. Are architects up-to-date on the specific needs of today's chemistry teacher and the laboratories they work in? Do they understand what is required to design a science lab in the 21st century? Do architects understand the need to have great laboratory ventilation, a separate room where you can safely store laboratory chemicals, ample preparation area and ample space at student lab stations so overcrowded conditions won't cause accidents?

We've developed a list of requirements we think make for an efficient and safe chemistry laboratory. This list by no means is complete, but it will give you a good start. Please remember that many of your design questions and concerns can be solved by calling Flinn Scientific. Our staff is ready to help answer your questions. Call us toll-free at 1-800-452-1261.

Chemistry Laboratory

1. Will the laboratory have a fume hood? Will the fume hood have gas, electricity, water and a sink? Where will the fume hood be located in the laboratory? A good rule of thumb is to keep the fume hood away from heavy student traffic areas and main exits.
2. Table tops should be black epoxy resin.
3. Floors should be vinyl tile. Properly installed, they are easily cleaned and relatively chemical resistant. Consider using nonskid wax. Carpet should never be used in a chemistry laboratory!
4. A handicap access lab station should be provided in at least one chemistry lab.
5. Ventilation in the chemistry lab is a must. Each laboratory must have its own ventilation purge fan that removes at least 3,200 cubic feet of air per minute. These fans should be vented directly to the outside and should not be interconnected between rooms. An on/off switch should be provided that allows the instructor to turn the fan on and off depending on the types of activities being conducted. The fans are not intended to be run all day long but on an as-needed basis. Your ultimate goal with a purge fan is to have a complete room air change in five minutes. The positioning of the fan will depend on your laboratory design. Remember fume hoods are not designed for general lab ventilation!
6. Make sure you have plenty of electrical outlets with ground fault interruption.
7. Will computer cables be run to each lab station for future use of computers?
8. Knowing that these labs are being built to last 30 or more years, should the lab be designed to include some common features so biology and physics may be taught there?
9. A fire blanket, fire extinguisher (ABC type), eyewash and a shower or body drench (with drain) should be placed in labs where hazardous chemicals will be used. Depending on where the teacher's demonstration table is located in relation to the general lab area, you may need two eyewashes, fire blankets and fire extinguishers.
10. Will you have a demonstration table? Will it have water, electricity, gas and a sink? A large sink is always nice to have in a demonstration table.
11. Master utility cut-off valves for gas and electricity are essential. Make sure they can be accessed easily in case of emergency.
12. Where will goggles be stored? Where will students hang or store their aprons?
13. Look at furniture designs that maximize student spacing at each lab station.
14. Good sight lines are critical for a chemistry teacher. Can you see most of the lab activity from one vantage point? Can you move easily from one lab station to another without going around student desks and chairs? Your ability to supervise students' lab activity must not be compromised.
15. Do you have ample storage for apparatus, hardware, equipment, etc.?
16. Are sinks a usable size? Do you want hot and cold water at each lab station?
17. All safety equipment must be marked with location placards/signs.
18. Do you need nonreactive waste receptacles? Fireproof trash cans?
19. Where will spill control materials be stored in the laboratory?
20. Do you want laboratory stools? For safety and space issues, stools are not used in many labs.
21. Do you want dry erase boards or chalkboards in the lab? Where do you want them located?
22. Does your state require two exits? If so, where will they be located?
23. Will the laboratory have ample lighting? Having 75–100 foot-candles is suggested at bench level.
24. Do exit doors have sturdy locks and self-closing return hardware?
25. Contact the five major laboratory furniture companies listed at the bottom of page 701. They are all fine companies that will provide free assistance in designing your labs. Their catalogs are valuable resources and provide lots of ideas. Make good use of these free resources.

CHEMISTRY LABORATORY DESIGN continued on next page.

Chemistry Laboratory Design, continued

Preparation/Chemical Storage Area

26. Will the preparation area have gas, electricity, water and a sink?
27. The preparation area should have a fire blanket, eyewash, fire extinguisher and possibly a body drench or shower.
28. Spill control materials should be located close to your main preparation area.
29. The prep/storage area should have a vinyl tile or concrete floor, double drywall ceiling and walls. The door should have self-return hardware with an automatic lock and a fire-rated door. The door should swing out if it is your only exit. You don't want the door to be blocked from opening if an "event" were to occur in this area. Signs on the door should say "Authorized Personnel Only."
30. A stepladder should be provided to help retrieve items from the top shelves.
31. Will your preparation area have a water still or water demineralizing system? If so, where will it be located?
32. Consider installing drying racks for glassware above the sink.
33. A good preparation area is just like your kitchen at home. You want plenty of counter and storage space.
34. Will a telephone or intercom system be available in case of emergency? You need a method to contact outside help.
35. There should be emergency lighting in the prep/chemical storage area in case the power goes out. If your labs do not have windows, emergency lighting should also be provided in the lab area.
36. Have smoke detectors installed in the chemical stores area and in an adjacent hallway. Both units should be line operated and go off together should fire/smoke develop in this area. This smoke alarm system will alert others in the school that a problem has developed.
37. Some architects are now installing acid dilution basins in chemistry labs. These can create a potential problem. Dilution basins should be checked, cleaned and recharged every six months to a year. If not, they could turn into a "chemical dump" or "hazardous waste site" and cause costly problems, (e.g., OSHA fines, clean-up costs). Does your state's law require that an acid dilution basin is put in the chemistry lab?
38. Will the prep area have a first aid kit?
39. Do you use laboratory carts? If so, the prep area should have space where the carts can be stored when not in use.
40. Consider building a separate chemical stores area next to the preparation area. Contained and secured chemical storage solves lots of problems.
41. Approved flammable liquid and acid storage cabinets should be in the chemical stores area.
42. Shelves in the chemical stores area should be firmly secured to the walls. Shelves should have a lip on the front to prevent bottles from rolling off.
43. Chemicals should not be stored more than six feet above the floor.
44. The chemical storage door should be a solid-core, fire-rated door (preferably hinged out). The door should have a good lock and be labeled to identify hazardous contents to alert and protect firefighters. Interior walls and the ceiling should be double drywall to make this a fire-rated room.
45. Chemical storeroom ventilation is a must. Four air changes per hour is a minimum. Air should be "pulled" from floor level and be exhausted directly to the outdoors.

The proper design of a chemistry lab can be very time-consuming. Acquaint yourself with as many ideas as possible and decide which ideas best fit your needs. Consider visiting other schools to look at their chemistry labs. What do other chemistry teachers like or dislike about their labs?

Contact the five major laboratory furniture companies discussed shown below. Their resources and ideas are invaluable.

Finally, depend on Flinn Scientific for suggestions, advice and help. We know what it takes to design a new chemistry lab and will be more than happy to help you.

IF YOU LIKE OUR
CATALOG
REFERENCE
MANUAL
SEND US YOUR ORDER

Laboratory Furniture Companies You Should Contact When Designing a Chemistry Laboratory

This list of laboratory furniture companies is not exhaustive. All of the companies listed are large manufacturers offering complete lines of laboratory furnishings and have sales representation in almost every state. While the companies listed are all fine companies, this list should not be considered recommendations by Flinn Scientific, Inc.

CampbellRhea Institutional Casework Inc.
1865 N. Market Street, Paris, TN 38242 • (731) 642-4251 • www.campbellrhea.com

Diversified Woodcrafts, Inc.
P.O. Box 160, Suring, WI 54174–0160 • (920) 842-2136 • www.diversifiedinc.com

Kewaunee Scientific Equipment Corporation
P.O. Box 1842, Statesville, NC 28687 • (704) 873-7202 • www.kewaunee.com

Leonard Peterson
P.O. Box 2277, Auburn, AL 36831-2277 • (334) 821-6832 • www.lpco.com

Sheldon Division, General Equipment Manufacturers
P.O. Box 836, Crystal Springs, MS 39059 • (601) 892-2731 • www.sheldonlabs.com

The Dos and Don’ts of **Chemical Labeling**

Information on What’s Required to Make Your Lab Safe

In 1983, OSHA implemented the Hazard Communication Standard (Right-to-Know law). This standard gives teachers, students and parents the Right-to-Know about the hazards associated with the chemicals they are using in the classroom/laboratory. The standard requires chemical manufacturers to transmit this safety information to their customers by the means of labels and Safety Data Sheets (SDSs).

In March 2012, OSHA updated the Hazard Communication Standard to incorporate the Globally Harmonized System of Classification and Labeling of Chemicals, better known as GHS. GHS provides a set of objective criteria for classifying the physical and health hazards of chemicals. Hazardous chemical labels will be required to include pictograms, a signal word and specific hazard and precautionary statements. The pictograms, signal words and hazard statements will help you quickly identify and describe the nature of the hazard(s). Precautionary statements provide guidance to prevent accidents and avoid exposure to chemicals. There are eight pictograms, shown below. In addition to the pictograms, GHS requires the use of signal words, either Danger or Warning, to heighten awareness of the relative risk when using certain chemicals. (Danger is the more severe warning!) Depending on their hazard rankings, not all chemicals will have a pictogram or signal word. GHS also assigns specific hazard statements to chemicals and applicable precautionary statements to prevent accidents and minimize exposure.

A well-written and designed chemical label will reduce accidents and may even save lives. For more than 40 years, you have counted on Flinn Scientific labels to help you safely store, handle and use laboratory chemicals. We naturally embraced the opportunity to further improve chemical safety by adding the GHS label elements while preserving the indispensable Flinn storage, disposal, shelf-life and hazard alert advice. See pages 24–25 for a GHS-compliant Flinn Scientific label and a convenient guide to using this information.

Chemical Labels in Your Laboratory

You may be wondering, “What about the chemicals I already have and the solutions I prepare for my lab?” GHS-formatted labels are the responsibility of the chemical manufacturer and distributor. You do not have to reproduce proper GHS-formatted labels, and you don’t have to relabel any chemicals you currently have in your storeroom. You must, however, ensure that the hazards of any chemical are easy to recognize and understand. We suggest the best approach to proper chemical-container labeling is to list these four items on the label:

1. **Chemical Name**—Spell out the name correctly and completely. Avoid using abbreviations or chemical formulas.
2. **Concentration**—If the chemical is in solution, indicate the solution’s molarity or strength.
3. **How can the chemical hurt you?**—List in clear terms how the chemical can hurt you and what target organs will be affected. This information easily can be found on your SDS or in the *Flinn Scientific Catalog/Reference Manual*. Avoid numerical or alphabetical codes. These codes are difficult to remember and could easily be misinterpreted. Use words that everyone will understand.
4. **Date Prepared**—Knowing the date the chemical was prepared is very important, especially for those chemicals that have a limited shelf life or become more hazardous with age.

For example, let’s say you just prepared a 6 M hydrochloric acid solution. The label should say:

Hydrocholoric Acid, 6 M solution
Corrosive to all body tissue, especially skin and eyes. Avoid all body contact.
2020

FLINN EXCLUSIVE

Flinn **Online Chemventory**™

Chemical Inventory Management System

The Flinn Online Chemventory™ is a cloud-based laboratory chemical inventory system that allows multiple users access to the database from multiple locations and multiple devices! Maintaining an accurate laboratory chemical inventory has never been easier, more flexible and more convenient.

Catalog No.	Description	Price/ Database License
SE2998	Flinn Online Chemventory™, 1-Year License	$ 99.00
SE2999	Flinn Online Chemventory™, 3-Year License	249.00
SE3000	Flinn Online Chemventory™, 5-Year License	349.00

Additional information may be required in your state. A few states require the National Fire Protection Association (NFPA) code on the label. Other states may require the Chemical Abstract Services (CAS) number to be on the label.

Finally, remember that this label may need to be on the chemical container for years to come. Avoid using grease pencils and writing directly on the bottle. Always use a permanent marker on label paper that has a good adhesive. Print clearly so everyone can read and understand the label you have prepared.

If you have questions regarding how to label chemical containers, please call us toll free at 1-800-452-1261. We’ll gladly help in any way we can.

GHS Pictograms

Acutely toxic
Copper(II) Chloride

Oxidizer
Ammonium Nitrate

Gas under pressure
Oxygen

Corrosive to skin or eyes
Hydrochloric Acid

Explosive or self-reactive substance
Not in school science labs!

Irritant to skin, eyes or respiratory tract
Iodine

Flammable or self-reactive
Methyl Alcohol

Carcinogen, mutagen or reproductive toxin
Formaldehyde

GHS STICKERS
SEE PAGE 669

GHS pictogram stickers can be used to create GHS labels. Attach these handy stickers to chemical bottles to quickly indicate hazards to the user. They come in a package of eight sheets with 63 stickers per sheet.

Practical Solutions to **Reduce Your Liability**

Introduction

Teaching science is different than teaching other academic subjects because to properly teach science, students must receive instruction and engage in appropriate hands-on activities. More importantly, science teachers must teach in an environment using materials and equipment that have the potential to cause serious harm to both teacher and student. Science teachers must be trained in more than just teaching methods and classroom management. They also must receive specific training in laboratory safety. Science teachers must know, understand and follow many rules and regulations to ensure the safety of students in their classrooms. Science teachers also owe it to their students to properly supervise, instruct, maintain equipment and facilities and warn students of potential harm in their classrooms. Accidents will happen in the classroom. However, teachers can significantly reduce their risk of negligence liability and prevent classroom mishaps by following a few simple rules.

1. *Know the safety statutes that affect your classroom and carefully abide by them.*

   Check with your state and county departments of education, state department of labor or Occupational Safety and Health Administration for statutes and regulations that apply to your classroom. At a minimum, each school should have in place an up-to-date Chemical Hygiene Plan (CHP) that describes the safety procedures that are required at your school.

2. *Document all efforts to resolve safety issues in your classroom.*

   Any safety issues or equipment problems that need repair must be documented carefully in writing and submitted to the proper administrator for immediate action. If you cannot successfully resolve the issue at the site level, send a letter to the superintendent or school board describing the problem, your efforts to correct the condition and possible solutions for resolving the problem. Attach copies of your documentation. Save all letters and documentation.

3. *Do not leave your classroom during any instructional period.*

   Every teacher has a primary duty to properly supervise students. Never leave students unsupervised for any reason.

4. *All students should wear the appropriate personal protective equipment while working in the laboratory.*

   Chemical splash goggles and chemical-resistant aprons should be worn whenever any chemicals (no matter how minimal the risk of perceived injury) are to be used by students. Protective eyewear must be worn during all laboratory activities and demonstrations.

5. *Teach safety all year and review safety procedures often.*

   Teachers have a duty to provide proper safety instruction. Start the year with a student safety contract then get in the habit of reviewing a safety rule every day at the beginning of class. It is critical to review the appropriate safety precautions with students prior to beginning any laboratory activity. Remember to document all safety instruction you provide in your lesson plan book.

6. *Make safety a priority in the classroom by establishing and modeling safe chemical-handling practices.*

   Set a good example for your students by always wearing appropriate personal protective equipment and performing laboratory procedures in a safe manner. Not only will your actions speak louder than words to your students, but if an injury to a student occurs, their attorney will not be able to use your good practices against you.

7. *Use smaller volumes and amounts of chemicals.*

   Smaller chemical quantities result in smaller spills, reduced vapors and less material for disposal. Smaller chemical quantities also usually result in less severe injuries to your students. Microscale as many labs as possible, particularly those that use volatile or hazardous chemicals.

8. *Demand appropriate safety training related to your duty of care in the science classroom.*

   Science laboratories are industrial areas requiring specialized training and knowledge that must be updated frequently. Your school district is responsible for appropriate training to enable you to meet your duty of care in the classroom.

9. *Do not permit students to use damaged or defective equipment.*

   Damaged or defective equipment can cause serious harm to students. Until the equipment can be repaired, do not use it. If the conditions of your laboratory facility are unsafe, then document the safety issues and do not permit laboratory activities until the conditions are remedied. Perhaps calling the safety issue to the attention of parents, whose students will not receive adequate instruction because of existing unsafe conditions, may achieve quicker resolution of the problem.

10. *Do not permit students to take chemicals or any other school equipment home to perform “experiments.”*

    Theft of unlocked chemicals, performance of unauthorized experiments and unsupervised home experiments expose students to potential injury and teachers to negligence liability.

11. *Be proactive rather than reactive.*

Acknowledgment

Kelly Ryan was a science teacher in San Gabriel High School in California for 17 years and is now a practicing attorney. He has written a book entitled *Science Classroom Safety and the Law—A Handbook for Teachers.*

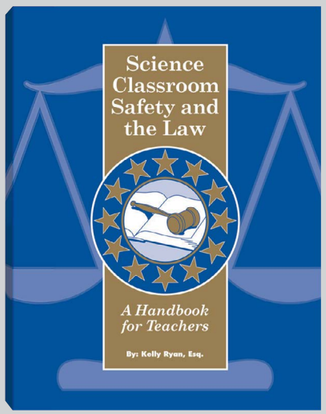
Science Classroom Safety and the Law—A Handbook for Teachers

By: Kelly Ryan, Esq., Attorney at Law

Science Classroom Safety and the Law was written to educate science teachers about court cases that apply to science education so you can successfully persuade school administrators to make the “right” decision regarding science safety. This book will give you the “ammunition” you need to correct safety problems at your school. Author Kelly Ryan understands firsthand the safety problems science teachers face since he was a high school chemistry teacher for 17 years before becoming an attorney.

Throughout the book, practical suggestions are made to improve science safety and reduce the potential for teacher and school district liability.

Catalog No.	Description	Price/Each
AP6118	Science Classroom Safety and the Law	$30.52



Helping Students Comply With **Safety Rules**

The student safety contract, which should be signed by both the student and a parent or guardian, is the foundation of the laboratory science safety program in the school. It is not enough, however, to set the rules and to "cover" them on the first or second day of class. Safety rules should be reviewed continuously throughout the school year, and they must be consistently enforced on a daily basis.

DID YOU KNOW? The Flinn Scientific Student Safety Contract is available in both a middle school and a high school version and also in Spanish! Visit the Flinn Scientific website at www.flinnsci.com to download copies of the appropriate safety contract.

Start With Safety!

Here are some ideas teachers have shared with us for reviewing the student safety contract and helping students remember the safety rules.

1. At the start of every class, read aloud one rule from the safety contract. By discussing safety every day, your students quickly will learn that safety is indeed your No. 1 priority! Reading one rule daily will allow you to review the entire safety contract three times over the course of the school year.
2. Incorporate safety into each laboratory exercise. Begin each lab period with a discussion of the chemicals, equipment and procedures used in the experiment and the safety precautions that must be observed. Pay special attention to nonroutine hazards, such as working with dissection equipment, that students may not encounter during every lab period. Prelab assignments are an ideal mechanism to ensure that students are prepared for lab and understand the safety precautions.
3. Have students make safety posters, and decorate the classroom or lab with the students' artwork. Seeing their own bright, colorful safety posters throughout the lab will help remind students that safety is important for you and for themselves! Sure, you could buy posters, but how much better to engage the students and gain their perspectives. This is a great assignment for a "substitute-teacher day." Provide paper, markers and poster board and have students make safety posters to illustrate the rules in the student safety contract. You will be amazed at the students' creativity, insight—and humor!
4. Record all safety instruction in your lesson plan. Every time you discuss safety in class, take a moment to write down in your lesson plan book what you talked about. Your lesson plan is a very valuable document should you ever have to prove that you are a responsible science teacher.

Regular and routine review of the safety rules will increase both student and teacher awareness of their safety in the lab and in the classroom. Make safety a habit!

Enforcing the Safety Rules

Make sure students know the rules and, more importantly, that there are consequences if they break the rules. All safety rules must be enforced consistently without discrimination.

Many teachers will issue a verbal warning or "safety ticket" for a first rule violation. If a second violation occurs during the same lab period, the student may be removed from the lab and given a zero for the day. If a student repeatedly disregards the safety rules, you must make the consequences more severe. The student may serve a detention or in-school suspension, and the student's parents or guardian should be notified. Having the parents remind the students that they also signed the safety contract is often all it takes to correct the behavior. Repeated violations of the safety contract should be dealt with by the school administration.

Students who do not follow the safety rules endanger not only themselves but all of their fellow students. Courts have ruled that the teacher and the school will be considered negligent if they do not enforce safety rules on a consistent basis.

Make Safety a Habit

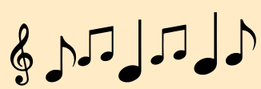
We are grateful to teachers who have shared their time-tested ideas for ensuring student compliance with safety. You know these ideas will work!

- Make safety a team effort! Empower lab teams to be responsible for each member's behavior. If a group member violates a safety rule, the entire group is warned and ultimately penalized. Peer pressure being what it is, you will find that the students themselves, rather than you, will begin to enforce the safety rules in the lab.
- Have students be in charge of presenting the safety lesson for a lab or classroom activity. Rotate this assignment among all the lab groups in the class so every group presents one safety lesson per quarter. Who knows better than teachers that the best way to learn something is to have to teach it!
- Students who wear their goggles around their necks or as "forehead protectors" should be assigned to wear their goggles during the next regular class period whether it's a test, a group activity or a lecture.
- Anyone caught not wearing their goggles must sing the "Goggle Song" in front of the class. Alternatively, have the entire class sing the song.

The Goggle Song

The Goggle Song is sung to the tune of "I'm a Little Teapot."

I'm a little chemist,
Short and stout,
Here are my goggles,
Here are my eyes.



If I don't wear my goggles, my teacher shouts:
Put them on or you get out!

Chemical **Spill Control**

Prevent and Respond to Laboratory Chemical Spills

No matter what precautions you take, sooner or later an accidental chemical spill will occur. A responsible science teacher will take steps to prevent spills, make sure proper safety equipment is available to contain and control the spill and understand how to use the safety equipment.

Spill Prevention

The first precaution to take for spill control is spill prevention. Experiments and laboratories should be designed to minimize the possibility of chemical spills. Experiments should use the minimal amount of chemicals whenever possible. The less chemical available, the smaller the spill.

Store and dispense chemicals in unbreakable bottles, such as plastic or PVC-coated glass bottles. Highly toxic materials should be stored in a secondary containment device, such as a *Chem-Saf*™ bag (heavy-duty plastic bag) or a *Saf-Stor*™ can (metal paint can). If a bottle is dropped, secondary containment will contain the spill and may actually prevent the spill from occurring.

Spill Control Equipment

Proper spill control equipment includes fire blankets, spill control materials (e.g., sand, absorbent and neutralizer) and a mercury spill control kit.

A 100% wool fire blanket is an excellent spill control device because it will contain and control a spill and its vapors. If a spill occurs and other spill control materials are not available, simply throw the fire blanket over the spill. The blanket will begin to absorb the liquid, contain the vapor and enable a person to walk over the spill without slipping. Remember, acid spilled on a tile floor will make the floor very slippery—the potential for slipping and falling into the acid spill is a real danger.

Every lab should have spill control materials that contain at least three components: sand, an absorbing agent and a neutralizer. Spill control materials should be capable of handling a spill from the largest bottle used in your laboratory, which is usually a 2.5-L acid bottle (remember, Murphy's Law states that the largest bottle is the one that will break). Sand is used to contain a spill, provide traction and prevent the spill from rapidly spreading across the tile floor. The absorbent contains and absorbs the liquid spill so it is easier to clean up, transport and dispose. Neutralizer is usually a base, such as sodium carbonate or calcium hydroxide, and is used to neutralize inorganic acid spills. If strong bases are used in your laboratory, it is also a good idea to keep a supply of citric acid on hand to neutralize base spills. A 2.5-kg bottle of citric acid is large enough to neutralize the entire contents of almost any bottle of base.

To save money, a homemade spill control kit is easily prepared using three 5-gallon plastic buckets. Fill the first 5-gallon bucket with 30 pounds of clean, dry sand (available as play sand at a discount or hardware store). Fill a second 5-gallon bucket with a 20-lb bag of unodorized kitty litter or oil absorbent. Fill the last bucket with 30 lbs of sodium carbonate, anhydrous, also known as soda ash. Soda ash is available at industrial chemical, building supply and swimming pool supply distributors. Label each bucket with the contents, and cover the top with plastic wrap to keep the contents fresh and so they aren't used as garbage cans. Place a plastic broom, plastic dustpan and several large heavy-duty plastic garbage bags near the spill control kit for cleanup and disposal.

If mercury or mercury thermometers are used in your classroom, mercury spill control materials should be readily available. Mercon spill control spray, wipes and sponges are available from Flinn and are ideal for cleaning up mercury spills. Small droplets of mercury also can be cleaned up by sprinkling zinc dust on the spill area. Zinc dust reacts with mercury to form a very stable and safe amalgam that is easy to handle and safe to dispose of in the trash.

Spill Control Procedures and Training

A written contingency plan on how to handle chemical spills should be part of every school's Chemical Hygiene Plan. The following procedure is an example of a contingency plan.

1. Quickly assess the spill, its hazards and the danger to yourself and your students and take appropriate action. If the spilled chemicals are unknown, assume the worst and evacuate.
2. Notify other laboratory personnel of the accident and, if necessary, evacuate the area. The safety of you and your students is always the top priority.
3. Tend to any injured or contaminated person and request help if necessary. If the chemical is splashed into an eye or onto skin, immediately irrigate using an eyewash or shower. If the chemical is splashed on your clothes, you may have time to first contain the spill with a fire blanket or spill control materials and then treat yourself. Remember, if you use a safety shower near a chemical spill, the water may expand the spill area.
4. Take steps to contain and limit the spill if this can be done without risk of injury or contamination.
5. Clean up the spill using appropriate procedure. Dispose of contaminated materials properly.
6. Call in emergency personnel if at any time your safety or your students' safety is in jeopardy.

To contain and control a chemical spill, the following procedure works well. Gently pour sand around the spill and onto the spill. The sand will contain the spill, prevent it from spreading and also provide traction if you need to walk over it. Next pour absorbent (kitty litter, oil absorbent) around the spill and onto the spill. This will absorb the liquid and also begin to contain any vapors. For both the absorbent and sand, it is best to gently drop or sprinkle the spill control material around the spill and then onto the spill to avoid spreading the spill. Lastly, if the spill is an inorganic acid or base, apply the appropriate neutralizer around the spill and onto the spill. The neutralizer needs to be mixed well with the sand and absorbent to come in contact with all of the spilled chemical—use a plastic broom to mix well.

After the spill is controlled, students are evacuated and injuries are addressed, then the clean-up begins. If the material is warm or still giving off vapors, ventilate the room and wait before cleaning up. Use a plastic dustpan and plastic broom to sweep up the now solid mess and place it into large, heavy-duty garbage or leaf bags for disposal. If at any time during the chemical spill containment or clean-up step you don't feel comfortable, leave the area and get help.

Make spill control containment and clean-up part of your annual safety training. Simulate a chemical spill with water and use sand as the control material. Note how quickly the "spill" spreads. Practice applying the spill control material around and then onto the spill. Determine the most convenient location for storing your spill control materials. Training is one of the most important components of an effective safety program.

Chemical spills will occur in you laboratory. With proper equipment, procedures and training, most spills can be prevented, and the spills that do occur can be handled safely and effectively.

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Dissection **Safety**

Dissection is an important part of many biology and life science courses. Properly planned dissection activities with clear learning goals allow students to observe similarities and differences among organisms and improve student understanding of anatomy and physiology. Dissection safety requires knowledge of preservatives and preserved materials, careful attention to safety precautions, availability of required safety equipment and proper tools, instruction of dissection procedures and advanced planning for clean-up and disposal.

General Guidelines

The rationale for dissection work should be well thought out and available in written form to answer any student or community questions that may arise. Careful and clearly written directions are important for safe and meaningful dissection work. Some school districts or states may require that teachers provide alternative learning activities with full credit for students who do not participate in dissection labs.

Preservatives and Preserved Materials

Preserved specimens only should be purchased from reputable suppliers to ensure that organisms have been obtained in a responsible manner and handled in accordance with U.S. Department of Agriculture regulations and guidelines. Most specimens are initially fixed in formaldehyde, which chemically cross-links proteins and prevents cellular enzymes from breaking down tissues and organs. Fixation using formaldehyde results in the hardening of the tissues and creates more durable specimens. After the fixing process, excess formaldehyde is generally removed and replaced with a safer preservative that contains alcohol or propylene glycol. Formaldehyde is a known human carcinogen, and formaldehyde vapors are highly irritating to the eyes, skin and respiratory tract. Flinn Scientific laboratory specimens are packaged to the industry's highest standards and are 99.7% free of residual formaldehyde.

Rinsing procedures are usually specified with specimens. Follow directions carefully, especially if the preserved materials will be used over an extended period of time. With the extremely low levels of preservative in most specimens, odors are minimal, but the expected lifetime of a preserved specimen is also shortened. A certain degree of preservative odor is likely to linger—good ventilation of the laboratory is thus critical to protect the health and well-being of teachers and students engaged in dissection activities. Work with the school administration to ensure that laboratory ventilation is adequate to provide fresh air and to confine any lingering odor to the laboratory rather than to the entire school. Store all preserved materials in locked cabinets or stockroom to restrict student access. Keep the specimens in their original containers, and inspect all preserved materials before use. Discard any decaying or damaged specimens.

Safety Precautions and Dissection Procedures

- Wear chemical-resistant gloves, chemical-resistant aprons and chemical splash goggles or safety glasses for all dissection activities. Work in a well-ventilated lab only. Open the windows, if possible, and turn on the hood if one is available. There should be absolutely no eating, drinking or gum-chewing during dissection activities.
- Use only quality dissection tools that are sharp and free of rust. Scalpels are the preferred instruments—use single-edge scalpels with rigid, reinforced handles for increased safety. Handle scalpels, razor blades and other sharp instruments with care, and do not use excessive force when working with or cleaning sharp instruments.
- Inspect dissection tools on a routine basis. Dull and dirty scissors, scalpels or blades are much more dangerous than sharp, clean ones. Discard any damaged instruments that cannot be repaired.
- Rinse formaldehyde specimens with water before dissecting—keep specimens moist but not drenched. Use wet paper towels or a few milliliters of a formaldehyde substitute, such as Formalternate® or water, to wet the specimen during dissection. Do not use formaldehyde.
- Instruct students on proper dissection techniques and procedures as well as how to dispose of sharps. Always cut away from the body and away from other people. Reposition the specimen or move to ensure safety.
- Properly mount specimens to the dissection pan or tray. Do not dissect a specimen while holding it. Cut gently, and avoid using excessive force. Deep cuts are more dangerous and may slice through internal organs. Use scissors to cut bones, including the rib cage. Dissection pins are used to hold the skin back and improve visibility—they do not hold the specimen to the tray. The specimen may slide during dissection if too much pressure is used.
- Wash hands frequently and before leaving the laboratory. Teach students about the potential for inadvertent contamination when they are working with preserved specimens even while wearing gloves. Once a glove has touched the specimen or instrument, it is contaminated. Avoid unconscious gestures, such as scratching the face or adjusting safety glasses. Sanitize safety glasses as needed.

Cleanup and Disposal

- Provide adequate time for proper cleanup and disposal of all dissection materials and the lab. Rinse dissection tools and pans after each use. If dissection pans contain rubber inserts, wash and dry them separately.
- Remove scalpel blades at the end of each dissection unit and carefully dispose of them in a sharps container. Clean instruments with Alconox® detergent solution (1 teaspoon Alconox mixed with 1 L water) rinse with water, and dry thoroughly. Wash countertops with dilute Lysol® or bleach solution.
- Rinse specimens thoroughly with water and double-bag, along with gloves and disposable aprons, in opaque garbage bags. Discard in an appropriate, secure container.
- Local conditions (e.g., septic systems) and regulations will determine the proper procedure for disposal of preserved materials. Teachers and administrators have a responsibility to be fully aware of all state and local regulations governing the disposal of laboratory and biological waste.

Dissection Instruments—Classroom Set
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Dissection Instruments—Classroom Set

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Laboratory Solution **Preparation**

Many of the reagents used in science are in the form of solutions that need to be purchased or prepared. For many purposes, the exact value of concentration is not critical; in other cases, the concentration of the solution and its method of preparation must be as accurate as possible. The Flinn Laboratory Solution Preparation reference section is designed for both the novice and experienced solution maker. It provides valuable information on the basic concepts of preparing solutions and instructions for preparing most solutions required in the high school science laboratory. Professional-quality solutions are possible when high-quality and fresh chemicals and solvents are used and meticulous procedures are followed. Many of the solutions described in this section are available ready-made from Flinn Scientific to save valuable laboratory preparation time.

The section is divided into several parts for your convenience.

- Basic Concepts of Preparing Solutions
- Preparation of Simple Inorganic Salt Solutions
- Preparations of Acid and Base Solutions
- Recipes for Biological, Histological and Chemical Solutions

Basic Concepts of **Preparing Solutions**

Molarity

The most common unit of solution concentration is **molarity (M)**. The molarity of a solution is defined as the number of moles of solute per one liter of solution. Note that the unit of volume for molarity is *liters,* not milliliters or some other unit. Also note that one liter of solution contains both the solute and the solvent. Molarity, therefore, is a ratio between moles of solute and liters of solution. To prepare laboratory solutions, usually a given volume and molarity are required. To determine molarity, the formula weight or molar mass of the solute is needed. The following examples illustrate the calculations for preparing solutions.

If starting with a solid, use the following procedure:

1. Determine the mass in grams of one mole of solute, the molar mass, MM_s.
2. Decide volume of solution required, in liters, V.
3. Decide molarity of solution required, M.
4. Calculate grams of solute (g_s) required using Equation 1.

   Eq. 1. $g_s = MM_s \times M \times V$

   Example: Prepare 800 mL of 2 M sodium chloride.

   $(MM_{NaCl} = 58.45\ g/mol)$

   $g_{NaCl} = 58.45\ g/mol \times 2\ mol/L \times 0.8\ L$

   $g_{NaCl} = 93.52\ g\ NaCl$
5. Dissolve 93.52 g of NaCl in about 400 mL of distilled water, then add more water until final volume is 800 mL.

If starting with a solution or liquid reagent:

1. When diluting more concentrated solutions, decide what volume (V_2) and molarity (M_2) the final solution should be. Volume can be expressed in liters or milliliters.
2. Determine molarity (M_1) of starting, more concentrated solution.
3. Calculate volume of starting solution (V_1) required using Equation 2.
   Note: V_1 must be in the same units as V_2.

   Eq. 2. $M_1V_1 = M_2V_2$

   Example: Prepare 100 mL of 1.0 M hydrochloric acid from concentrated (12.1 M) hydrochloric acid.

   $M_1V_1 = M_2V_2$

   $(12.1\ M)(V_1) = (1.0\ M)(100\ mL)$

   $V_1 = 8.26\ mL$ conc. HCl
4. Add 8.26 mL of concentrated HCl to about 50 mL of distilled water, stir, then add water up to 100 mL.

Percent Solutions

Mass percent solutions are defined based on the grams of solute per 100 grams of solution.

Example: 20 g of sodium chloride in 100 g of solution is a 20% by mass solution.

Volume percent solutions are defined as milliliters of solute per 100 mL of solution.

Example: 10 mL of ethyl alcohol plus 90 mL of H_2O (making approx. 100 mL of solution) is a 10% by volume solution.

Mass-volume percent solutions are also very common. These solutions are indicated by w/v% and are defined as the grams of solute per 100 milliliters of solution.

Example: 1 g of phenolphthalein in 100 mL of 95% ethyl alcohol is a 1 w/v% solution.

BASIC CONCEPTS OF PREPARING SOLUTIONS continued on next page.

Basic Concepts of Preparing Solutions, continued

Conversion Between Percent Solutions

You may wish to convert mass percent to volume percent or vice versa. If so, follow this procedure:

A 10% by mass solution of ethyl alcohol in water contains 10 g of ethyl alcohol and 90 g of water.

1. The formula for determining the volume of the component (ethyl alcohol in our example) is:

$$\text{Volume} = \frac{\text{mass of ethyl alcohol}}{\text{density of ethyl alcohol}}$$

2. Determine the volume of the total solution by dividing the mass of the solution by the density of the solution.
3. Determine the percent by volume by dividing the volume of the component by the volume of the solution.

Let's solve 1, 2 and 3 as follows:

1. Mass of ethyl alcohol = 10 g (given)

   Density of ethyl alcohol = 0.794 g/mL (from handbook)

$$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

$$\text{Volume of ethyl alcohol} = \frac{10\text{ g}}{0.794\text{ g/mL}} = 12.6\text{ mL}$$

2. Mass of solution = 100 g (given)

   Density of solution (10% ethyl alcohol) = 0.983 g/mL (from handbook)

$$\text{Volume of solution} = \frac{100\text{ g}}{0.983\text{ g/mL}} = 101.8\text{ mL*}$$

3. Volume percent of solution

$$\text{Percent} = \frac{\text{volume of ethyl alcohol}}{\text{total volume of solution}} = \frac{12.6}{101.8} = 12.4\%$$

Reverse the procedure to convert volume percent to mass percent.

Calculating Molarity From Percent Solutions

To determine the molarity of a mass percent solution, the density of the solution is required. Use the following procedure:

1. Determine the mass of solution by multiplying the volume of the solution by the density of the solution.

   mass = volume x density

2. Determine concentration in percent by mass of the solute in solution. *Change to the decimal equivalent.*
3. Calculate the molar mass of the compound, MM.
4. Multiply mass (step 1) by mass % (step 2) and divide by molecular mass (step 3) to find the number of moles present in the whole solution.
5. Divide the number of moles (step 4) by the volume in liters of the solution to find the molarity of the solution.

   Example: Determine molarity of 37.2% hydrochloric acid (density 1.19 g/mL).

1. Mass of solution = 1,000 mL x 1.19 g/mL = 1,190 g
2. Mass % = 37.2 % = 0.372
3. Molar mass of hydrochloric acid = 36.4 g/mol
4. $\frac{\text{mass x mass \%}}{MM_{HCl}} = \frac{1{,}190\text{ g x }0.372}{36.4\text{ g/mol}} = 12.1\text{ moles}$
5. Molarity = moles/liters = 12.1 moles/1 liter = 12.1 M

* The volume percent statement generally is accurate but the volume percent is not always calculated directly from the volumes of the mixed ingredients because the final volume may not equal the sum of the separate volumes. In our solution (No. 2) note that if the alcohol volume (12.6 mL) is added to the water volume (90 mL), the final volume is less than 102.6 mL.

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Definitions

Buffer: A solution that tends to maintain a constant pH when excess acid or base is added.

Concentrated: For some commonly used acids and bases, the maximum solubility (at room temperature) in an aqueous solution or as a pure liquid.

Concentration: The relative amount of solute and solvent in a solution.

Hydrates: Compounds containing water chemically combined in a definite ratio. Computations using formula weight must take the water molecules into account.

Miscible: The ability of two liquids to be completely soluble in one another.

Molality: A concentration unit (m); defined as the number of moles of solute divided by the number of kilograms of solvent.

Molar Mass: The mass of a mole of any element or compound.

Molarity: A concentration unit (M); defined as the number of moles of solute divided by liters of solution.

Normality: A concentration unit (N); defined as the number of equivalents of solute per liter of solution (e.g., 1 M H_2SO_4 = 2 N H_2SO_4).

Saturated Solution: A solution that contains the maximum amount of a particular solute that will dissolve at that temperature.

Solute: The substance that is dissolved or has gone into solution (typically a solid).

Solution: A uniform homogeneous mixture of two or more substances. The individual substances may be present in varying amounts.

Solvent: The substance which does the dissolving (typically a liquid, such as water or alcohol). Must be greater than 50% of the solution.

Standard Solution: A very precise solution, usually to 3–4 significant figures, used in quantitative analysis or an analytical procedure.

Supersaturated Solution: A solution that contains more solute than equilibrium conditions allow; it is unstable and the solute may precipitate upon slight agitation or addition of a single crystal.

Preparation of Simple Inorganic Salt Solutions

Name / Formula / F.W.	Concentration	g/L
Aluminum chloride $AlCl_3 \cdot 6H_2O$ 241.43	0.2 M 0.05 M	48.3 g 12.1 g
Aluminum nitrate $Al(NO_3)_3 \cdot 9H_2O$ 375.13	0.1 M	37.5 g
Aluminum sulfate $Al_2(SO_4)_3 \cdot 18H_2O$ 666.42	0.1 M	66.6 g
Ammonium acetate $NH_4C_2H_3O_2$ 77.08	1.0 M 0.1 M	77.1 g 7.7 g
Ammonium chloride NH_4Cl 53.49	1.0 M 0.5 M	53.5 g 26.7 g
Ammonium nitrate NH_4NO_3 80.04	1.0 M 0.5 M 0.1 M	80.0 g 40.0 g 8.0 g
Ammonium sulfate $(NH_4)_2SO_4$ 132.1	0.1 M	13.2 g
Barium chloride $BaCl_2 \cdot 2H_2O$ 244.28	0.1 M	24.4 g
Barium hydroxide $Ba(OH)_2 \cdot 8H_2O$ 315.50	0.1 M	31.5 g
Barium nitrate $Ba(NO_3)_2$ 261.35	0.5 M 0.1 M	130.7 g 26.1 g
Bismuth nitrate $Bi(NO_3)_3 \cdot 5H_2O$ 485.1	0.1 M	48.5 g in 500 mL 6M HNO_3*
Bismuth trichloride $BiCl_3$ 315.34	0.2 M	63.1 g in 500 mL 3M HCl*
Cadmium chloride $CdCl_2 \cdot 2\frac{1}{2}H_2O$ 228.34	0.1 M	22.8 g
Cadmium nitrate $Cd(NO_3)_2 \cdot 4H_2O$ 308.49	0.1 M	30.8 g
Calcium acetate $Ca(C_2H_3O_2)_2 \cdot H_2O$ 176.19	0.5 M 0.1 M	88.1 g 17.6 g
Calcium chloride $CaCl_2 \cdot 2H_2O$ 147.02	1.0 M 0.1 M	147.0 g 14.7 g
Calcium hydroxide $Ca(OH)_2$ 74.10	saturated	2 g†
Calcium nitrate $Ca(NO_3)_2 \cdot 4H_2O$ 236.16	0.5 M 0.1 M	118.1 g 23.6 g
Chromium(III) chloride $CrCl_3 \cdot 6H_2O$ 266.48	0.1 M	26.6 g
Chromium(III) nitrate $Cr(NO_3)_3 \cdot 9H_2O$ 400.18	0.1 M	40.0 g
Cobalt(II) chloride $CoCl_2 \cdot 6H_2O$ 237.95	0.1 M	23.8 g
Cobalt(II) nitrate $Co(NO_3)_2 \cdot 6H_2O$ 291.05	0.1 M	29.1 g
Copper(II) chloride $CuCl_2 \cdot 2H_2O$ 170.49	0.5 M 0.1 M	85.2 g 17.0 g
Copper(II) nitrate $Cu(NO_3)_2 \cdot 3H_2O$ 241.6	0.5 M 0.1 M	120.8 g 24.2 g
Copper(II) sulfate $CuSO_4 \cdot 5H_2O$ 249.69	1.0 M 0.5 M	249.7 g 124.8 g
Iron(II) sulfate $FeSO_4 \cdot 7H_2O$ 278.03	0.01 M	2.8 g and 1 mL conc. H_2SO_4*
Iron(III) chloride $FeCl_3 \cdot 6H_2O$ 270.32	1.0 M 0.1 M	270.3 g 27.0 g
Iron(III) nitrate $Fe(NO_3)_3 \cdot 9H_2O$ 404.00	0.1 M	40.4 g

* Add solid to acid solution, stir, then add to water. Dilute to 1 L. Remember, always add acid to water.

† Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Lead acetate $Pb(C_2H_3O_2)_2 \cdot 3H_2O$ 379.34	0.1 M	38.0 g
Lead chloride $PbCl_2$ 278.12	saturated	12.0 g†
Lead nitrate $Pb(NO_3)_2$ 331.2	1 M	331.2 g§
	0.5 M	165.6 g
	0.1 M	33.1 g
Lithium carbonate Li_2CO_3 73.89	0.1 M	7.4 g
Lithium chloride LiCl 42.40	1.0 M	42.4 g
	0.1 M	4.2 g
Lithium nitrate $LiNO_3$ 68.95	1.0 M	69.0 g
	0.5 M	34.5 g
Magnesium bromide $MgBr_2 \cdot 6H_2O$ 292.25	0.1 M	29.2 g
Magnesium chloride $MgCl_2 \cdot 6H_2O$ 203.33	1.0 M	203.3 g
	0.1 M	20.3 g
Magnesium hydroxide $Mg(OH)_2$ 58.34	saturated	300 g†
Magnesium nitrate $Mg(NO_3)_2 \cdot 6H_2O$ 256.43	0.1 M	25.6 g
Magnesium sulfate $MgSO_4 \cdot 7H_2O$ 246.50	0.5 M	123.3 g
	0.1 M	24.7 g
Manganese chloride $MnCl_2 \cdot 4H_2O$ 197.91	0.5 M	99.0 g
	0.1 M	19.8 g
Manganese sulfate $MnSO_4 \cdot H_2O$ 169.01	0.2 M	33.8 g
	0.1 M	16.9 g

Name / Formula / F.W.	Concentration	g/L
Nickel chloride $NiCl_2 \cdot 6H_2O$ 237.72	0.25 M	59.4 g
	0.1 M	23.8 g
Nickel nitrate $Ni(NO_3)_2 \cdot 6H_2O$ 290.82	1 M	290.8 g
	0.2 M	58.2 g
Nickel sulfate $NiSO_4 \cdot 6H_2O$ 262.87	1.0 M	262.9 g
	0.5 M	131.4 g
Potassium bromide KBr 119.02	0.5 M	59.5 g
	0.1 M	11.9 g
Potassium carbonate K_2CO_3 138.21	0.5 M	69.1 g
	0.1 M	13.8 g
Potassium chloride KCl 74.56	0.5 M	37.3 g
	0.1 M	7.5 g

* Add solid to acid solution, stir, then add to water. Dilute to 1 L. Remember, always add acid to water.

† Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

§ Use 7.5 mL conc. HNO_3 to help dissolve.

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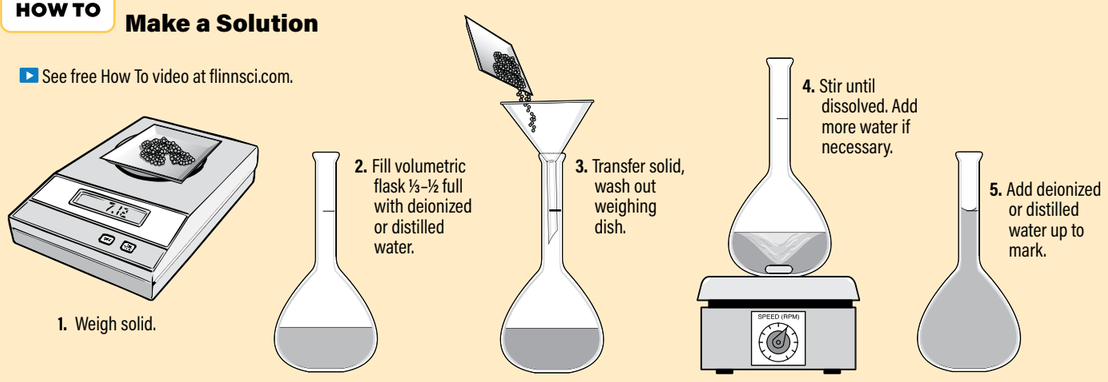
Catalog No.	Description	Price/ Database License
SE2998	Flinn Online Chemventory™ 1-Year License	$ 99.00
SE2999	Flinn Online Chemventory™ 3-Year License	249.00
SE3000	Flinn Online Chemventory™ 5-Year License	349.00

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

HOW TO **Make a Solution**

See free How To video at flinnsci.com.



1. Weigh solid.
2. Fill volumetric flask ⅓–½ full with deionized or distilled water.
3. Transfer solid, wash out weighing dish.
4. Stir until dissolved. Add more water if necessary.
5. Add deionized or distilled water up to mark.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Potassium chromate K_2CrO_4 194.21	1.0 M	194.2 g
	0.5 M	97.1 g
	0.1 M	19.4 g
Potassium dichromate $K_2Cr_2O_7$ 294.22	0.1 M	29.4 g
Potassium ferricyanide $K_3Fe(CN)_6$ 329.26	0.5 M	164.6 g
	0.1 M	32.9 g
Potassium ferrocyanide $K_4Fe(CN)_6 \cdot 3H_2O$ 422.41	0.1 M	42.2 g
Potassium hydrogen phthalate $KHC_8H_4O_4$ 204.23	0.1 M	20.4 g
Potassium hydroxide see page 741		
Potassium iodate KIO_3 214.01	saturated	214.0 g†
	0.2 M	42.8 g
	0.1 M	21.4 g
Potassium iodide KI 166.01	1 M	166.0 g
	0.5 M	83.0 g
	0.2 M	33.2 g
Potassium nitrate KNO_3 101.11	0.5 M	50.6 g
	0.1 M	10.1 g
Potassium permanganate $KMnO_4$ 158.04	0.2 M	31.6 g
	0.1 M	15.8 g
	0.01 M	1.6 g
Potassium phosphate, monobasic KH_2PO_4 136.09	0.1 M	13.6 g
Potassium phosphate, dibasic K_2HPO_4 174.18	0.1 M	17.4 g

Name / Formula / F.W.	Concentration	g/L
Potassium phosphate, tribasic K_3PO_4 212.27	0.1 M	21.2 g
Potassium sulfate K_2SO_4 174.27	0.5 M	87.1 g
	0.1 M	17.4 g
Potassium thiocyanate KSCN 97.18	1.0 M	97.2 g
	0.5 M	48.6 g
	0.1 M	9.7 g
Silver nitrate $AgNO_3$ 169.87	0.5 M	84.9 g
	0.1 M	17.0 g
Sodium acetate $NaC_2H_3O_2 \cdot 3H_2O$ 136.08	1 M	136.1 g
	0.5 M	68.0 g
Sodium bicarbonate $NaHCO_3$ 84.01	0.5 M	42.0 g
	0.1 M	8.4 g
Sodium borate $Na_2B_4O_7 \cdot 10H_2O$ 381.42	4 %	40.0 g
Sodium bromide NaBr 102.90	1.0 M	102.9 g
	0.1 M	10.3 g
Sodium carbonate Na_2CO_3 105.99	saturated	214.0 g†
	1.0 M	106.0 g
	0.1 M	10.6 g
Sodium carbonate $Na_2CO_3 \cdot H_2O$ 124.00	1.0 M	124.0 g
	0.1 M	12.4 g

* Add solid to acid solution, stir, then add to water. Dilute to 1 L. Remember, always add acid to water.

† Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

General Solubility Rules **for Inorganic Compounds**

Nitrates (NO_3^-): All nitrates are soluble.

Acetates ($C_2H_3O_2^-$): All acetates are soluble; silver acetate is moderately soluble.

Bromides (Br^-), **Chlorides** (Cl^-) and **Iodides** (I^-): Most are soluble except for salts containing silver, lead and mercury.

Sulfates (SO_4^{2-}): All sulfates are soluble except barium and lead. Silver, mercury(I) and calcium are slightly soluble.

Hydrogen sulfates (HSO_4^-): The hydrogen sulfates (aka bisulfates) are more soluble than the sulfates.

Carbonates (CO_3^{2-}), **phosphates** (PO_4^{3-}), **chromates** (CrO_4^{2-}) and **silicates** (SiO_4^{2-}): All carbonates, phosphates, chromates and silicates are insoluble, except those of sodium, potassium and ammonium. An exception is $MgCrO_4$, which is soluble.

Hydroxides (OH^-): All hydroxides (except lithium, sodium, potassium, cesium, rubidium and ammonium) are insoluble; $Ba(OH)_2$, $Ca(OH)_2$ and $Sr(OH)_2$ are slightly soluble.

Sulfides (S^{2-}): All sulfides (except sodium, potassium, ammonium, magnesium, calcium and barium) are insoluble. Aluminum and chromium sulfides are hydrolyzed and precipitate as hydroxides.

Sodium (Na^+), **potassium** (K^+) and **ammonium** (NH_4^+): All sodium, potassium, and ammonium salts are soluble (except some transition metal compounds).

Silver (Ag^+): All silver salts are insoluble. Exceptions are $AgNO_3$ and $AgClO_4$. $AgC_2H_3O_2$ and Ag_2SO_4 are moderately soluble.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Sodium chloride	saturated	390.0 g†
NaCl	1.0 M	58.5 g
58.45	0.1 M	5.8 g
Sodium dichromate	0.1 M	29.8 g
$Na_2Cr_2O_7 \cdot 2H_2O$		
298.03		
Sodium fluoride	0.1 M	4.2 g
NaF		
41.99		
Sodium hydroxide see page 691		
Sodium iodide	0.5 M	75.0 g
NaI	0.1 M	15.0 g
149.92		
Sodium nitrate	0.5 M	43.0 g
$NaNO_3$	0.1 M	8.5 g
84.99		
Sodium oxalate	0.1 M	13.4 g
$Na_2C_2O_4$		
134.00		
Sodium phosphate, monobasic	0.1 M	13.8 g
$NaH_2PO_4 \cdot H_2O$		
137.99		
Sodium phosphate, dibasic	0.5 M	134.0 g
$Na_2HPO_4 \cdot 7H_2O$	0.1 M	26.8 g
268.07		
Sodium phosphate, dibasic	0.5 M	71.0 g
Na_2HPO_4	0.1 M	14.2 g
141.96		
Sodium phosphate, tribasic	0.1 M	38.0 g
$Na_3PO_4 \cdot 12H_2O$		
380.12		
Sodium sulfate	saturated	600 g†
$Na_2SO_4 \cdot 10H_2O$	1.0 M	322.2 g
322.19	0.5 M	161.1 g

Name / Formula / F.W.	Concentration	g/L
Sodium sulfate	saturated*	260 g†
Na_2SO_4	1.0 M	142.0 g
142.02	0.5 M	71.0 g
Sodium sulfide	2.0 M	48.0 g§
$Na_2S \cdot 9H_2O$	1.0 M	24.0 g
240.18		
Sodium sulfite	1.0 M	126.1 g
Na_2SO_3		
126.05		
Sodium thiosulfate	0.5 M	124.1 g
$Na_2S_2O_3 \cdot 5H_2O$	0.1 M	24.8 g
248.19		
Strontium chloride	0.5 M	133.3 g
$SrCl_2 \cdot 6H_2O$	0.1 M	26.7 g
266.64		
Strontium hydroxide	saturated	220 g†
$Sr(OH)_2 \cdot 8H_2O$		
266.82		
Strontium nitrate	1.0 M	211.6 g
$Sr(NO_3)_2$	0.5 M	105.8 g
211.63		
Tin(II) chloride	0.1 M	22.6 g in 1 M HCl*
$SnCl_2 \cdot 2H_2O$		
225.65		
Tin(IV) chloride	0.1 M	35.1 g in 3 M HCl*
$SnCl_4 \cdot 5H_2O$		
350.61		
Zinc chloride	0.5 M	68.1 g and 1 mL 12 M HCl*
$ZnCl_2$		
136.29	0.1 M	13.6 g
Zinc nitrate	0.5 M	149.7 g
$Zn(NO_3)_2 \cdot 6H_2O$	0.1 M	29.7 g
297.49		
Zinc sulfate	1.0 M	287.6 g
$ZnSO_4 \cdot 7H_2O$	0.1 M	28.8 g
287.56		

* Add solid to acid solution, stir, then dilute to 1 L. Remember, always add acid to water.

† Approximate amount for 1 L of saturated solution. Keep adding solute until it no longer dissolves; stir for 1 hour, then filter.

§ Use hot water, stir vigorously.

HOW TO

Increase the Rate of Dissolving Solids

A solvent will only dissolve a limited quantity of solute at a definite temperature. However, the rate at which the solute dissolves can be accelerated by the following methods:

1. Pulverize or grind up the solid to increase the surface area of the solid in contact with the liquid.
2. Heat the solvent. This will increase the rate of solution because the molecules of both the solvent and the solute move faster.
3. Stir vigorously.

Combinations of all three methods, when practical, will dissolve solids more quickly.

Distilled or Deionized Water—Which Do I Need?

Distilled water is free of inorganic materials, suspended impurities and most organic contaminants. To make or buy distilled water is expensive. While there may be school laboratory applications where distilled water is required, in many applications, deionized (aka demineralized) water will do just as well. Deionized water, like distilled water, is free of inorganic materials and most suspended contaminants. If you need organic-free water, buy a still or buy distilled water.

Preparation of Acid Solutions

Name / Formula / F.W.	Concentration	Amount/Liter§
Acetic Acid*	6 M	345 mL
CH_3CO_2H	3 M	173
F.W. 60.05	1 M	58
99.7%, 17.4 M	0.5 M	29
sp. gr. 1.05	0.1 M	5.8
Hydrochloric Acid*	6 M	500 mL
HCl	3 M	250
F.W. 36.4	1 M	83
37.2%, 12.1 M	0.5 M	41
sp. gr. 1.19	0.1 M	8.3
Nitric Acid*	6 M	380 mL
HNO_3	3 M	190
F.W. 63.01	1 M	63
70.0%, 15.8 M	0.5 M	32
sp. gr. 1.42	0.1 M	6.3
Phosphoric Acid*	6 M	405 mL
H_3PO_4	3 M	203
F.W. 98.00	1 M	68
85.5%, 14.8 M	0.5 M	34
sp. gr. 1.70	0.1 M	6.8
Sulfuric Acid*	9 M	500 mL†
H_2SO_4	6 M	333†
F.W. 98.08	3 M	167†
96.0%, 18.0 M	1 M	56
sp. gr. 1.84	0.5 M	28
	0.1 M	5.6

* Always add acid to water. The addition of acid to water is an exothermic reaction. Use high temperature (e.g., Pyrex®) glassware.

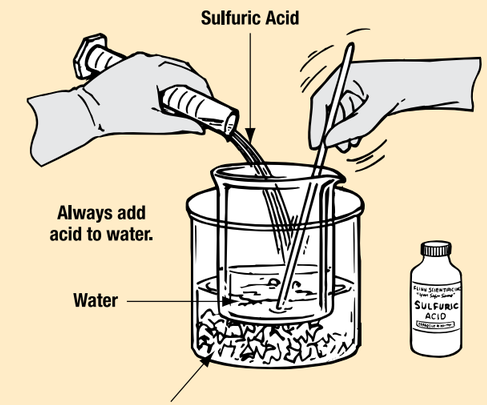
† Extremely exothermic, submerge mixing vessel in an ice bath. See adjacent box.

§ The amount of solute required to prepare one liter of solution.

Preparing Sulfuric Acid Solution?

Always **ADD ACID (AA)** to water! A great amount of heat is liberated when sulfuric acid is added to water. The temperature of the solution will rise rapidly. In fact, the temperature may rise so fast that the solution will boil and possibly spatter a strongly acidic solution. Consider immersing your mixing vessel in a bucket of ice to control the solution temperature. Always add the acid to water ***very*** slowly while stirring continuously.

▶ See free How To video at flinnsci.com.



Safe Storage of Acids

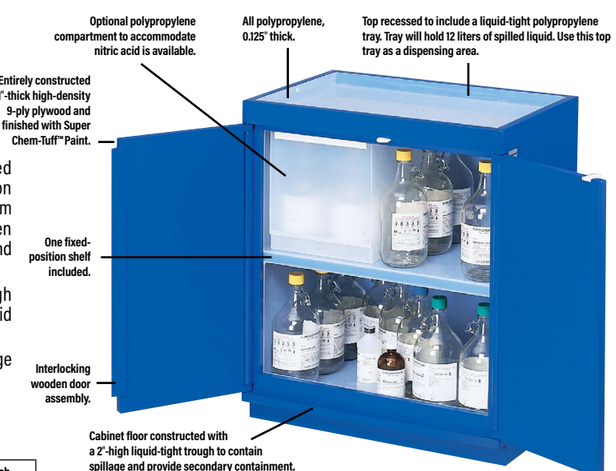
Flinn/SciMatCo® Wooden Acid Cabinets are Ideal for School Storerooms

Corrosive chemicals, such as strong acids and bases, must be isolated from other chemicals to prevent accidental contact and hazardous reaction conditions. The best way to isolate your corrosive chemicals is to store them in an approved corrosive storage cabinet like the Flinn/SciMatCo® wooden acid cabinet. Locked storage cabinets also provide security against theft and vandalism.

Flinn/SciMatCo® wood acid cabinets are designed specifically for high school chemical storerooms. Made from 9-ply, high-density plywood, Flinn acid cabinets are guaranteed never to rust or corrode.

Flinn/SciMatCo® acid cabinets will provide long life and safe, secure storage for all your corrosives. See pages 644–645 for more information.

▶ See free video at flinnsci.com.



Catalog No.	Description	Price/Each
SE8041	Flinn/SciMatCo® Acid Cabinet; Wood; interior PARTIALLY lined with polypropylene (floor, shelf and top tray)	$ 1250.00*
SE8051	Flinn/SciMatCo® Acid Cabinet; Wood; interior COMPLETELY lined with polypropylene (floor, interior walls, interior top and top tray)	1450.00*

* Must be shipped by motor truck freight.

Flinn Acid Cabinets

- Wooden acid cabinets are safer and more durable than metal cabinets.
- Acid attacks ALL metal cabinets.
- No metal is used anywhere in the interior construction of Flinn/SciMatCo® acid cabinets.

Preparation of Base Solutions

Name / Formula / F.W.	Concentration	Amount/Liter§
Ammonium Hydroxide*	6 M	405 mL
NH_4OH	3 M	203
F.W. 35.05	1 M	68
	0.5 M	34
	0.1 M	6.8
Potassium Hydroxide	6 M	337 g
KOH	3 M	168
F.W. 56.11	1 M	56
	0.5 M	28
	0.1 M	5.6
Sodium Hydroxide†	6 M	240 g
NaOH	3 M	120
F.W. 40.00	1 M	40
	0.5 M	20
	0.1 M	4.0

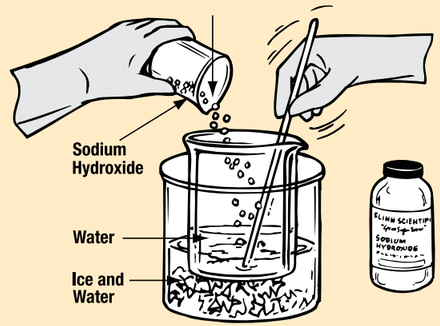
* Use concentrated (14.8 M) ammonium hydroxide.

† Exothermic reaction. Use high temperature (borosilicate) glassware.

§ The amount of solute required to prepare one liter of solution.

Preparing Sodium Hydroxide Solution?

A great amount of heat is liberated when sodium hydroxide and water are mixed. The temperature of the solution may rise very rapidly. In fact, the temperature may rise so fast that the solution may boil and possibly spatter a hot, caustic solution. Immerse the flask or beaker in an ice–water bath to control the solution temperature. In addition, pay special attention to the condition of the beaker or flask, you use to prepare these solutions. If you use a glass vessel it must be borosilicate glass and it must be free of any scratches, chips or breaks. Inspect the vessel carefully before use. Add ingredients slowly with continuous stirring.



Flinn Chemicals **Make Teaching Science Safer!**

Many science teachers spend too much time and energy complying with regulations concerning the use, storage and handling of laboratory chemicals. Flinn Scientific's unique chemical packaging and labeling meet or exceed these regulations, allowing you more time to do what you do best... teach science! Depend on Flinn Scientific to fulfill all of your chemical needs.

A Concentrated acids are packaged in Flinn *Saf-Cubes*™ for safe shipping and storage.

B Innovative packaging like E-Z Drop™ bottle allow for safe storage and easy dispensing.

C Reactive metals are packaged in plastic bottles inside plastic bags and placed in special metal cans for safe storage.

D Flinn *Chem-Saf*™ bags and desiccant packets are standard on many Flinn chemicals.

E A CD with up-to-date and specifically designed SDSs for science teachers is included with your first chemical order each year.

F A free Flinn Exclusive lab safety poster is also included with your first chemical order of each year!

Recipes for Biological, Histological and **Chemical Solutions**

Aceto-Carmine (Schneider)
Place 0.5 g of carmine and 55 mL of DI water in a 200-mL flask, bring to a boil and add 45 mL of glacial acetic acid. Plug flask with cotton wool, boil again, cool and filter. *(stain and fixative, good for protozoa and nuclei)*

Aceto-Orcein Staining Solution
Heat 31.5 mL of glacial acetic acid and 13.5 mL of DI water almost to boiling. When acid is hot, add 2 g of synthetic orcein and allow to cool. Dilute by adding 55 mL of DI water; stir and filter. *(connective tissue stain)*

Adrenaline Hydrochloride
Dissolve 0.1 g of adrenaline hydrochloride in 100 mL of Ringer's solution.

Adipoyl Chloride/Hexane Solution
Dissolve 4.6 g of adipoyl chloride in approximately 50 mL of hexane, stir, then dilute to 100 mL with hexane. *(nylon demonstration)*

Agar (Non-nutrient)
Suspend 15 g of agar in 1 L of DI water. Heat to a boil and stir until completely dissolved. Let cool to 50–55 °C and then dispense into desired containers. Agar will firm as it cools. Must add a nutrient if using for culture growth.

Agarose Gel
The standard concentration of agarose in the gel is 0.8%—a concentration that offers a compromise between band resolution and running time. The following directions are for 100 mL of an 0.8% agarose solution. Stir 0.8 g of agarose into 100 mL of working strength (1X) electrophoresis buffer (TBE or TAE) in a glass Erlenmeyer flask. Stopper with nonabsorbent cotton or foam plug. Dissolve agarose by heating in a microwave (30–40 seconds, stir, repeat) or on a hot plate. Heat until solution is clear and agarose appears to be fully dissolved. Stir frequently and do not allow solution to boil for more than a few seconds. Prepare the casting tray, place the well comb and pour the gel(s) when the agarose solution has cooled to approximately 60 °C. Allow the gel to fully solidify on a flat, level surface for 20–30 minutes. Gel should be opaque and firm to the touch.

See page 49 for a complete listing of culture media.

Alizarin
0.1% methanol solution: Dissolve 0.1 g of alizarin in 50 mL of methyl alcohol, then dilute to 100 mL with methyl alcohol. *(pH indicator)*

Alizarin Red S
1% aqueous: Dissolve 1 g of alizarin red S in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Alizarin Yellow R
0.1% aqueous: Dissolve 0.1 g of alizarin yellow R in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Aluminon
Dissolve 0.1 g of aurin tricarboxylic acid in 100 mL of DI water. *(qualitative reagent for aluminum)*

Amylase
0.5% aqueous: Dissolve 0.5 g of amylase in 50 mL of DI water, then dilute to 100 mL. Prepare fresh. *(starch digestion)*

Aniline Blue Alcohol Stain
1% alcohol: Dissolve 1 g of aniline blue in 100 mL 85% ethyl alcohol. *(stain for cellulose)*

Aniline Blue Aqueous Stain
0.5% aqueous: Dissolve 0.5 g aniline blue in 50 mL DI water, then dilute to 100 mL. Filter if necessary. *(stain for algae and fungi)*

Aniline Blue Indicator
0.1% aqueous: Dissolve 0.1 g aniline blue in 50 mL DI water, then dilute to 100 mL. *(pH indicator)*

Baker's Softening Fluid
Mix 10 mL of glycerol, 54 mL of 95% ethanol and 35 mL DI water. *(softening of animal structures)*

Barfoed's Reagent
Add 10 mL of glacial acetic acid to 1 L of DI water and stir. Add 66.5 g of cupric acetate monohydrate. Heat and stir until solid is completely dissolved. *(test for glucose)*

Benedict's Qualitative Solution
Dissolve 173 g of sodium citrate dihydrate and 100 g sodium carbonate anhydrous in 800 mL DI water. Warm and stir to aid dissolution. Filter if necessary. In a separate container, dissolve 17.3 g copper(II) sulfate pentahydrate in 100 mL DI water. Slowly, while stirring constantly, add the copper sulfate solution to the first solution. Let cool and dilute to 1 L with DI water. *(test for the presence of simple sugars)*

Benedict's Quantitative Solution
Dissolve 18.0 g of copper(II) sulfate pentahydrate in 100 mL of DI water and set aside. Dissolve 100.0 g of sodium carbonate anhydrous, 200.0 g of sodium citrate dihydrate and 125 g of potassium thiocyanate in 800 mL DI water. Heat, if necessary, to aid dissolution of the solids. Allow the solution to cool, then transfer to a 1-L volumetric flask. Slowly, while stirring constantly, add the copper sulfate solution to the 1-L flask. Prepare a 0.1 M potassium ferrocyanide solution by dissolving 0.25 g of potassium ferrocyanide trihydrate in 5 mL of DI water. Add to the 1-L volumetric flask, stir, then dilute to 1 L with DI water. Filter if necessary. 25 mL of this solution is reduced by 50 mg of glucose.

Bial's Reagent (Sumner)
Add 4 drops of 10% iron(III) chloride solution to 100 mL of 6 M hydrochloric acid. Add 0.03 g of orcinol and stir. *(test for pentoses and glycuronic acids)*

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

SAFETY TIP

Become a Label Fanatic!

- Do not use chemicals from unlabeled containers.
- Do not place labels on top of one another.
- Label chemicals clearly and permanently.

An unlabeled container will become tomorrow's "Mystery Substance." A grease pencil or label can help eliminate a future problem and a lot of expense.

You Make It—You Label It!

Minimum label requirements:

1. Identity of contents
2. Concentration
3. Your name
4. Date of preparation (if applicable)
5. Hazard alert (if applicable)

Recipes for Biological, Histological and Chemical Solutions, continued

Bile Salts

5% aqueous: Dissolve 5 g of bile salts in 50 mL of DI water, dilute to 100 mL. Mix gently to avoid foam. *(digestive studies)*

Bismark Brown Y

0.5% aqueous: Dissolve 0.5 g of bismark brown Y in 50 mL of DI water, dilute to 100 mL, stir and filter if necessary. *(stain for protozoa)*

Biuret Test Solution

Dissolve 2.3 g of copper(II) sulfate pentahydrate in 230 mL of DI water. Set aside. Dissolve 308 g sodium hydroxide in 770 mL of DI water (very exothermic; cool vessel in an ice water bath) and cool to room temperature. Add all the copper sulfate solution to the sodium hydroxide solution. Solution should be blue. *(test for proteins)*

Blood Agar Base Infusion

Suspend 40 g of blood agar base infusion in 1 L of DI water. Heat to a boil while stirring vigorously. Boil for one minute. Sterilize for 15 min at 121 °C (15 lbs. of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and pour into sterilized culture dishes. *(culture medium)*

Borax

Add 4 g Borax (sodium borate, $Na_2B_4O_7 \cdot 10H_2O$) to 100 mL of DI water. Stir. *(preparation of slime)*

Borax Carmine

Dissolve 2 g of Borax (aka sodium tetraborate) in 50 mL of DI water, add 1.5 g of carmine and boil for 30 minutes. Let cool, make up to 50 mL with DI water, then add 50 mL of 70% ethyl alcohol. Let stand for a few days, then filter. *(good general stain for plant and animal tissue)*

Borax Methylene Blue

Heat 100 mL of DI water to 60 °C and stir in 2 g methylene blue and 5 g Borax. Allow to cool slowly. Solution improves with age. *(connective tissue stain, Negri bodies)*

Bouin's Fixative

Mix together 75 mL of saturated aqueous picric acid solution, 25 mL of commercial formalin (10% formaldehyde solution), and 5 mL of glacial acetic acid. *(plant and animal tissue fixative)*

Brilliant Blue R-250

Dissolve 0.25 g of Coomassie brilliant blue R-250 in 40 mL methyl alcohol. Add 40 mL DI water, then 7 mL concentrated acetic acid. Dilute to 100 mL with DI water. *(staining proteins in polyacrylamide and agarose gels for electrophoresis)*

Brilliant Blue G-250

Dissolve 0.1 g of Coomassie brilliant blue G-250 in 25 mL methyl alcohol. Add 40 mL DI water, then 5 mL acetic acid. Dilute to 100 mL with DI water. *(staining proteins in polyacrylamide and agarose gels for electrophoresis)*

Brilliant Cresyl Blue

Dissolve 0.85 g sodium chloride in 75 mL of DI water. Add 1 g brilliant cresyl blue and stir to dissolve. Dilute to 100 mL with DI water. *(vital stain, general stain for protozoa and plant cells)*

Brilliant Green

1% aqueous: Dissolve 1 g of brilliant green in 50 mL of DI water, dilute to 100 mL, stir and filter if necessary. *(stain for plant cytoplasm and pH indicator)*

Bristol's Solution

Dissolve 1 g of potassium dihydrogen phosphate, 1 g sodium nitrate, 0.3 g of magnesium sulfate, 0.1 g calcium chloride, 0.1 g sodium chloride and a trace of ferric chloride in 1 L of DI water. (culture of algae)

See page 59 for a complete listing of indicators and pH ranges.

Bromcresol Green

0.1% alcoholic: Dissolve 0.1 g of bromcresol green in 75 mL of ethyl alcohol, then dilute to 100 mL. *(pH indicator)*

Bromcresol Green

0.04% aqueous: Dissolve 0.04 g of bromcresol green in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Bromcresol Purple

0.04% aqueous: Dissolve 0.04 g of bromcresol purple in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Bromine Water

Add 1 mL of bromine to 200 mL of DI water and stir. Keep in a tightly sealed bottle. The shelf life is poor due to evaporation of bromine. *(polar/nonpolar solubility studies)*

Bromphenol Blue

0.04% aqueous: Dissolve 0.04 g of bromphenol blue in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Bromthymol Blue

0.04% aqueous: Dissolve 0.04 g of bromthymol blue in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Carbol Fuchsin (Ziehl-Nielson)

Dissolve 1 g of basic fuchsin in 10 mL of 100% ethyl alcohol (absolute); set aside. Dissolve 5 g of phenol in 100 mL of DI water. Add the two solutions together and stir. *(bacterial stain, bacterial spores and various cytoplasmic inclusions)*

Carnoy's Fluid

Mix together 10 mL glacial acetic acid, 30 mL of chloroform and 60 mL of 100% ethyl alcohol. *(fixative for tissue used in chromosome studies)*

Chlorophenol Red

0.04% aqueous: Add 23.5 mL of 0.01 M sodium hydroxide to 226.5 mL of DI water. Dissolve 0.1 g of chlorophenol red in this solution. *(pH indicator)*

Clayton Yellow

1% aqueous: Dissolve 1 g of Clayton yellow in 50 mL of DI water, then dilute to 100 mL. *(pH indicator and fluorescent dye for microscopy)*

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

HOW TO Prepare Buffer Solutions

Buffer solutions are available from Flinn as premade solutions and ready-to-mix capsules and envelopes. Buffers are typically mixtures of a weak acid and the salt of the acid or a weak base and its salt. This combination is called a conjugate acid–base pair, and it will resist changes in pH upon addition of small amounts of acid or base. Recipes for three common buffer solutions are provided.

pH 4: Dissolve 5.10 g of potassium hydrogen phthalate ($KHC_8H_4O_4$) in 250 mL of DI water, add 0.50 mL of 0.10 M hydrochloric acid, then dilute to 500 mL.

pH 7: Prepare 0.10 M potassium phosphate monobasic (KH_2PO_4) solution by dissolving 3.40 g in 250 mL DI water. Prepare 0.20 M sodium hydroxide solution by dissolving 0.8 g in 100 mL DI water. Mix 250 mL of the 0.10 M potassium phosphate solution and 73 mL of 0.2 M sodium hydroxide solution, then dilute to 500 mL.

pH 10: Prepare 0.025 M sodium borate solution ($Na_2B_4O_7 \cdot 10H_2O$) by dissolving 2.38 g in 250 mL of DI water. Prepare 0.20 M sodium hydroxide solution by dissolving 0.8 g in 100 mL DI water. Mix 250 mL of the 0.025 M sodium borate solution and 27 mL of the 0.2 M sodium hydroxide solution, then dilute to 500 mL.

Recipes for Biological, Histological and Chemical Solutions, continued

Congo Red Indicator

0.1% aqueous: Dissolve 0.1 g of Congo red in 50 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Congo Red Stain

1% aqueous: Dissolve 1 g of Congo red in 100 mL of DI to which a few drops of ammonium hydroxide solution have been added. *(plant tissue stain)*

m-Cresol Purple

Add 26.2 mL of 0.01 M sodium hydroxide to 200 mL of DI water. Dissolve 0.1 g of m-cresol purple in this solution, dilute to 250 mL. Can omit NaOH if using Na salt. *(pH indicator)*

Cresol Red

Add 26.2 mL of 0.01 M sodium hydroxide to 200 mL of DI water. Dissolve 0.1 g of cresol red in this solution, dilute to 250 mL. Can omit NaOH if using Na salt. *(pH indicator)*

Crystal Violet Indicator

0.02% aqueous: Dissolve 0.02 g of crystal violet in 80 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Crystal Violet Stain (Gram)

Dissolve 2 g of crystal violet in 20 mL of 95% ethyl alcohol. Dissolve 0.8 g of ammonium oxalate monohydrate in 80 mL of DI water and then mix with the crystal violet solution. Filter if necessary. *(used in Gram staining procedure for bacteria)*

Destaining Solution

Add 70 mL glacial acetic acid to 400 mL methanol. Dilute to 1 L with DI water. *(removes stains from polyacrylamide gels)*

Dichloroindophenol

Dissolve 0.025 g of 2,6-dichloroindophenol, sodium salt in 80 mL DI water, then dilute to 100 mL. Prepare fresh. *(indicator for Vitamin C)*

Diphenylamine Reagent

Mix 1 g of diphenylamine in 100 mL glacial acetic acid and 2.75 mL of concentrated sulfuric acid. Store in an amber bottle at 2 °C. Warm to room temperature before using. *(DNA/RNA extractions)*

EMB Agar

Suspend 36 g of EMB agar in 1 L of DI water and heat to boiling to dissolve the solid. Sterilize for 15 min at 121 °C (15 lbs. of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and swirl to disperse the precipitate just prior to pouring into sterilized culture dishes. *(culture medium)*

Eosin Y Indicator

1% alcoholic: Dissolve 1 g eosin Y in 80 mL 95% ethyl alcohol, then dilute to 100 mL. Stir and filter if necessary. *(fluorescent pH indicator)*

Eosin Y Stain

0.5% aqueous: Dissolve 0.5 g of eosin Y in approximately 80 mL DI water, then dilute to 100 mL. Stir and filter if necessary. Add a few drops of hloroform as preservative. *(good cytoplasmic stain)*

See page 59 for a complete listing of indicators and pH ranges.

Eriochrome Black T Indicator

1% alcoholic: Dissolve 1 g of eriochrome black T in 80 mL of 95% ethyl alcohol, dilute to 100 mL with 95% ethyl alcohol. *(indicator for EDTA titrations)*

Erythrosin B Indicator

1% alcoholic: Dissolve 1 g of erythrosin B in 80 mL of 95% ethyl alcohol, dilute to 100 mL with 95% ethyl alcohol. *(indicator for EDTA titrations)*

Erythrosin B Stain

1% aqueous: Dissolve 0.1 g of erythrosin B in 100 mL of DI water. Stir and filter if necessary. Add chloroform as a preservative. *(biological stain)*

Fast Green

Dissolve 2 g of fast green in 100 mL of DI water containing 2 mL of glacial acetic acid. *(tissue cell staining)*

Fehlings Solution A

Dissolve 34.6 g of copper(II) sulfate pentahydrate in 500 mL DI water. Combine solution A and B (1:1) just before use. *(test for reducing sugars and aldehydes)*

Fehlings Solution B

Dissolve 125 g of potassium hydroxide and 173 g of potassium sodium tartrate tetrahydrate in 500 mL of DI water. Combine solution A and B (1:1) just before use. *(test for reducing sugars and aldehydes)*

Ferroin Solution

Dissolve 0.23 g of iron(II) sulfate heptahydrate in 100 mL of DI water. Add 0.46-g of 1,10-phenanthroline monohydrate and stir until dissolved. *(redox indicator)*

Fluorescein

0.1% alcoholic: Dissolve 0.1 g of fluorescein in 80 mL of 95% ethyl alcohol, then dilute to 100 mL. *(fluorescent pH indicator)*

Formalin-Aceto-Alcohol (FAA)

Mix together 50 mL of 95% ethyl alcohol, 2 mL of glacial acetic acid, 10 mL of 40% formaldehyde and 40 mL of DI water. *(preservative for algae, also a fixative)*

Fuchsin, Acid, Indicator

1% aqueous: Dissolve 1 g of acid fuchsin in 80 mL of DI water, then dilute up to 100 mL. *(pH indicator)*

Fuchsin, Acid, Stain

1% aqueous: Dissolve 1 g of acid fuchsin in 100 mL of DI water and 1 mL of glacial acetic acid. Filter if necessary. *(staining marine algae and small crustaceans)*

Fuchsin, Basic

1% aqueous: Dissolve 1 g of basic fuchsin in 80 mL of DI water, then dilute to 100 mL. Filter if necessary. *(pH indicator and biological stain)*

Fuchsin, New

1% aqueous: Dissolve 1 g of new fuchsin in 80 mL of DI water, then dilute to 100 mL. Filter if necessary. *(biological stain)*

Gastric Juice

Dissolve 5 g pepsin, 8.75 g concentrated hydrochloric acid, and 2.5 g of lactic acid in 500 mL of DI water. Dilute to 1 L and stir gently to avoid foaming. *(digestive studies)*

Gibberellic Acid

Dissolve 100 mg of gibberellic acid in 5.0 mL of ethyl alcohol. Dilute to 1 L with DI water. *(plant growth hormone)*

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

HOW TO Set up a Prep Room

Equipment

- Electronic Balance
- Magnetic Stirrers
- Volumetric Flasks
- Graduated Cylinders
- Water Purification System
- Bottles
- Labels

Safety Essentials

- Eyewash/Body Drench
- Spill Control and Clean-up Materials
- Fire Extinguisher
- Chemical-Resistant Gloves and Aprons
- Chemical Splash Goggles
- Telephone Available for Emergency Use
- Chemical First Aid Kit
- Good Ventilation

See page 729 for a model storage/prep room diagram.

Recipes for Biological, Histological and Chemical Solutions, continued

Guar Gum
Dissolve 0.5 to 1.0 g of guar gum in 100 mL DI water. Make fresh. *(preparation of "slime")*

Hayem's Solution
Dissolve 0.25 g of mercury (II) chloride, 2.5 g of sodium sulfate, and 0.5 g of sodium chloride in 100 mL of DI water. *(diluting solution for red cell counts)*

Hematoxylin, Delafield's
Dissolve 4 g of hematoxylin in 25 mL of 100% ethyl alcohol. Add 400 mL of saturated aqueous aluminum ammonium sulfate solution. Expose to light for a few days in a cotton-stoppered bottle, then filter. Add 100 mL of methyl alcohol and 100 mL of glycerin. The stain must be ripened at room temperature for 2 months before use. Store in a well stoppered flask. *(good general stain for nonwoody plant tissue and animal tissue)*

Hexamethylenediamine/Sodium Hydroxide
Dissolve 60 g of 1,6-hexamethylenediamine in 500 mL of DI water. Add 20 g of sodium hydroxide, stir to dissolve and dilute to 1 L. *(nylon demonstration)*

Indigo Carmine
Dissolve 0.25 g of indigo carmine in 80 mL of 50% ethyl alcohol solution. Stir, dilute to 100 mL with 50% ethyl alcohol solution. Prepare fresh; shelf life is poor. *(pH indicator)*

Iodine, Tincture of
Dissolve 50 g of potassium iodide in 50 mL of DI water. Add 70 g iodine, stir to dissolve then dilute to 1 L with 95% ethyl alcohol. Store in a dark bottle.

Iodine–Potassium Iodide
Dissolve 15 g of potassium iodide in 125 mL of DI water. Add 3 g of iodine, stir to dissolve, then dilute to 1 L. Store in a dark bottle. *(starch test)*

HOW TO

Preparing an Iodine Solution?

Iodine crystals are not directly soluble in water, which is why most water-based iodine solutions call for potassium iodide as an ingredient. Iodine is soluble in potassium iodide solutions.

As a general rule, start with approximately one-fourth of the final volume of water and add the required amount of potassium iodide. Once the potassium iodide has dissolved, add the iodine crystals. Stir until completely dissolved and bring the solution up to its final volume.

Generally, the more concentrated the potassium iodide solution, the more readily the iodine crystals will dissolve. Iodine solutions should be prepared in a fume hood.

Always store iodine solutions in PVC-coated amber glass bottles.

Iodine Solution (0.05 M)
Dissolve 20 g of potassium iodide in 400 mL of DI water. Add 13 g of iodine, stir to dissolve, then dilute to 1 L. Store in a dark bottle.

Iodine Solution, Gram's
Dissolve 6.7 g of potassium iodide in 100 mL of DI water. Add 3.3 g of iodine, stir to dissolve, then dilute to 1 L. Store in a dark bottle. *(used in Gram staining procedure for bacteria)*

Iodine Solution, Lugol's
Dissolve 20 g of potassium iodide in 200 mL of DI water. Add 10 g of iodine, stir to dissolve then dilute to 1 L. Store in a dark bottle. *(General biological stain and vital stain stock solution, dilute 5:1 before use.)*

Knop's Solution
Add 1 g of potassium nitrate, 1 g of magnesium sulfate heptahydrate, 1 g of potassium phosphate dibasic and 3 g of calcium nitrate tetrahydrate to 500 mL distilled water. Stir then dilute to 1 L with distilled water. Shake solution before use to redissolve the calcium nitrate. Add 10 g of agar and 10 g of glucose to 500 mL of this solution for culturing algae. Only use distilled water when making this solution. *(culturing algae)*

Limewater
Add 25 g of calcium hydroxide to 1 liter of DI water and shake. Allow the solid to settle before use. Keep container tightly closed. *(detecting carbon dioxide gas)*

Litmus
0.5% aqueous: Dissolve 0.5 g of litmus in 80 mL of boiling DI water. Allow solution to cool to room temperature, dilute to 100 mL. Stir. Filter if necessary. *(pH indicator)*

Malachite Green
1% aqueous: Dissolve 1 g of malachite green oxalate in 50 mL of DI water. Stir gently to prevent foaming and dilute to 100 mL. Filter if necessary. *(pH indicator, stain for plant cytoplasm)*

Methyl Cellulose
3% aqueous: Heat 100 mL of DI water to 85 °C (not boiling), shake 3.0 g of methyl cellulose powder into hot water and stir rapidly while cooling the solution to 5 °C in an ice water bath. Solution is stable at room temperature, but store in tightly closed containers. *(slowing down protozoa for microscopy)*

Methylene Blue
1% aqueous: Dissolve 1 g of methylene blue in 75 mL of DI water, then dilute to 100 mL. *(pH indicator and stain)*

Methylene Blue, Loeffler's
Dissolve 0.3 g of methylene blue in 30 mL of 95% ethyl alcohol. Add 0.01 g of potassium hydroxide and 100 mL of DI water, stir and filter. *(bacterial stain)*

Methyl Green
1% aqueous, acidified: Dissolve 1 g of methyl green in 75 mL of DI water, add 1 mL of glacial acetic acid, then dilute to 100 mL with DI water. Stir, filter if necessary. *(1% acidified aqueous solution as a general nuclear stain, plant stain or cytoplasm stain)*

Methyl Orange
0.1% aqueous: Dissolve 0.1 g of methyl orange in 75 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Methyl Red
0.1% alcoholic: Dissolve 0.1 g of methyl red in 75 mL 95% ethyl alcohol, then dilute to 100 mL. *(pH indicator)*

Methyl Red
0.04% aqueous: Dissolve 0.1 g of methyl red in 11.8 mL of 0.02 M sodium hydroxide solution, then dilute to 250 mL with DI water. If using Na salt, omit NaOH. *(pH indicator)*

Methyl Violet 2B, Indicator
0.04% aqueous: Dissolve 0.1 g of methyl violet 2B in 200 mL of DI water, then dilute to 250 mL. *(pH indicator)*

Methyl Violet 2B, Stain
Dissolve 0.05 g of methyl violet 2B in 100 mL of 0.7% sodium chloride solution and 1 mL of 1 M acetic acid. Stir and filter if necessary. Use 0.9% sodium chloride solution if staining human blood cells. *(staining amphibian and human blood cells)*

Methyl Violet 6B, Indicator
1% aqueous: Dissolve 1 g of methyl violet 6B in 75 mL of DI water, then dilute to 100 mL. Stir and filter if necessary. *(biological stain)*

Millon Reagent
Dissolve 1 part by weight mercury in 2 parts concentrated nitric acid; when mercury has dissolved, add to 2 parts water; stir. **Note:** always add acid to water. *(test for proteins)*

Molisch Reagent
Dissolve 5 g 1-naphthol in 100 mL of 95% ethyl alcohol. *(test for aldehydes, sugars and carbohydrates)*

Neutral Red
Dissolve 0.1 g of neutral red in 60 mL of 95% ethyl alcohol, then dilute to 100 mL with DI water. Stir and filter if necessary. *(pH indicator and vital stain stock solution)*

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

Recipes for Biological, Histological and Chemical Solutions, continued

Nigrosin
Saturated: Dissolve 3 g of nigrosin (water soluble) in 100 mL of DI water. Stir and filter if necessary. *(biological stain for protozoa)*

Ninhydrin
Add 2.5 g of ninhydrin to 50 mL of n-butyl alcohol in a 600-mL beaker. Gently heat and stir the solution using a magnetic stirrer/hot plate in a fume hood until all the solid is dissolved. Dilute to 500 mL with n-butyl alcohol. Use extreme caution when heating n-butyl alcohol, extreme fire risk. *(test for proteins)*

m-Nitrophenol
0.3% aqueous: dissolve 0.3 g of m-nitrophenol in 75 mL DI water, then dilute to 100 mL. *(pH indicator)*

p-Nitrophenol
0.1% aqueous: dissolve 0.1 g of p-nitrophenol in 75 mL DI water, then dilute to 100 mL. *(pH indicator)*

4-(p-Nitrophenylazo) Resorcinol
Dissolve 0.01 g of 4–(p-nitrophenylazo) resorcinol in 100 mL of 1 M sodium hydroxide solution and stir. *(indicator solution for magnesium and molybdenum)*

Nutrient Agar
Mix together 23 g of nutrient agar with 1 L of DI water. Sterilize for 15 minutes at 121 °C (15 lbs of pressure) in an autoclave or pressure cooker. Nutrient agar should be sterilized if it is being used as culture media. Cool to 50–55 °C and pour into sterilized culture dishes. *(culture medium)*

Nutrient Agar (using plain agar)
Dissolve 5 g peptone, 3 g meat extract and 15 g of plain agar in 850 mL of distilled water. Adjust pH to 7.0. Bring to 1 L with distilled water. Autoclave or filter sterilize.

Orange G
1% aqueous: Dissolve 1 g of orange G in 75 mL of DI water, then dilute to 100 mL. Stir and filter if necessary. *(staining plant sections)*

Orange IV
0.1% aqueous: Dissolve 0.1 g of orange IV in 75 mL of DI water, then dilute to 100 mL. Stir and filter if necessary. *(pH indicator and biological stain)*

Orcein
Mix together 1 g of orcein, 1 mL of concentrated hydrochloric acid and 100 mL of 100% ethyl alcohol. Shake to dissolve, let sit over night and filter. *(stain for elastic fibers)*

Pancreatin
Dissolve 5.0 g of pancreatin in 500 mL of DI water, then dilute to 1 L. Add 0.5 M sodium bicarbonate solution dropwise until solution is neutral. *(digestive studies)*

Phenantholine
See Ferroin Solution, page 717.

Phenolphthalein
1% alcoholic: Dissolve 1 g of phenolphthalein in 50 mL of 95% ethyl alcohol, then dilute to 100 mL with 95% ethyl alcohol. For a 0.5% solution, only use 0.5 g of phenolphthalein. *(pH indicator)*

Phenol Red
0.02% alcoholic: Dissolve 0.1 g of phenol red in 400 mL of 95% ethyl alcohol, then dilute to 500 mL with 95% ethyl alcohol. *(pH indicator)*

Phenol Red, Sodium Salt
0.02% aqueous: Dissolve 0.1 g of phenol red, sodium salt in 400 mL of DI water, then dilute to 500 mL. *(pH indicator)*

Phloroglucinol
Mix 0.5 g phloroglucinol and 50 mL of DI water. Add 50 mL of concentrated hydrochloric acid and stir. Use within 5–7 days. Always add acid to water. *(test for pentose or galactose)*

Polyvinyl Alcohol
4% aqueous: Add 40 g of polyvinyl alcohol to 1 L of hot tap water. Microwave on high for about 2 minutes; stir and heat for additional 1–2 minute increments until dissolved. Allow solution to cool before use. *(preparation of "slime")*

Potato Dextrose Agar
Suspend 39 g of potato dextrose agar in 1 L of DI water. Heat to a boil while stirring constantly. Boil for 1 minute. Sterilize for 15 minutes at 121 °C (15 lbs of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and pour into sterilized culture dishes. If using for plate counts of yeasts and molds, adjust the pH to 3.5 with sterile 10% tartaric acid. *(culture medium for plate counts of yeasts and molds)*

Pyrogallol
Dissolve 80 g of potassium hydroxide in 65 mL of DI water, add 5 g of pyrogallol, stir, then dilute to 100 mL. Poor shelf life, make fresh. *(determining oxygen content)*

Resazurin
1% aqueous: Dissolve 1 g of resazurin in 50 mL DI water, then dilute to 100 mL. Stir and filter if necessary. *(biological stain and pH indicator)*

Richard's Solution
Dissolve 6.6 g of potassium nitrate, 3.3 g of potassium dihydrogen phosphate, 33.3 g sucrose and 1.7 g of magnesium sulfate in 1 L of DI water. *(culture of molds)*

Rhodamine B
1% aqueous: Dissolve 1 g of rhodamine B in 50 mL DI water, then dilute to 100 mL. Stir and filter if necessary. *(biological stain)*

Ringer's Solution for Frogs
Dissolve 0.14 g of potassium chloride, 6.5 g of sodium chloride, 0.12 g calcium chloride and 0.2 g sodium bicarbonate in 1 L of DI water. *(mounting fluid and examination of blood cells)*

Ringer's Solution for Mammals
Dissolve 0.42 g of potassium chloride, 9.0 g of sodium chloride, 0.24 g calcium chloride and 0.2 g sodium bicarbonate in 1 L of DI water. *(mounting fluid and examination of blood cells)*

Rose Bengal
1% aqueous: Dissolve 1 g of rose bengal in 50 mL DI water, then dilute to 100 mL with distilled water. Stir and filter if necessary. *(biological stain)*

Sabouraud Dextrose Agar
Suspend 65 g of sabouraud dextrose agar in 1 L of DI water. Heat to boiling while stirring. Boil for 1 minute. Sterilize for 15 minutes at 121 °C (15 lbs of pressure) in an autoclave or pressure cooker. Cool to 50–55 °C and pour into sterilized culture dishes. *(microbiological culture medium)*

Safranin O
Dissolve 0.1 g safranin in 75 mL of DI water, then dilute to 100 mL. Filter before use. *(Gram counter stain)*

Saline Solution
0.75% aqueous: Dissolve 7.5 g of sodium chloride in 750 mL of DI water, then dilute to 1 L. *(Saline solution for birds and invertebrates, use 0.8% for frogs and 0.9% for mammals)*

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

HOW TO

Slow Microorganisms

Solutions of methyl cellulose are commonly used in microscopy to slow the movements of microorganisms—making them more readily observable. Generally offered as a 2–3% solution in water, its high viscosity physically inhibits the organism. In use, the resulting dilution will depend on the amount of water present on the slide when the slowing agent is added. Some experimentation may be required to find the optimal dilution for a particular organism. One technique involves dropping the methyl cellulose onto a clean slide in the form of a ring. A drop of the culture being studied is then placed into the center of the ring and a cover glass applied. As an alternative, see the listing for polyvinyl alcohol solution.

Recipes for Biological, Histological and Chemical Solutions, continued

Seawater (Hale's)
Dissolve 23.991 g sodium chloride, 0.742 g potassium chloride, 2.240 g calcium chloride dihydrate, 10.893 g magnesium chloride hexahydrate, 9.10 g sodium sulfate decahydrate, 0.197 g sodium bicarbonate, 0.085 g sodium bromide, 0.018 g strontium chloride hexahydrate and 0.027 g boric acid in 800 mL DI water. Dilute up to 1 L. Final solution has a salinity of 34.33 0/00 (ppt) and a chlorinity of 19 0/00. *(not for aquaria, only for technical purposes)*

Seawater
Dissolve 29.42 g of sodium chloride, 0.5 g of potassium chloride, 3.22 g magnesium chloride, 0.56 g sodium bromide, 1.36 g calcium sulfate, 2.4 g magnesium sulfate, 0.11 g calcium carbonate and 0.003 g ferric oxide in 1 L DI water. *(not for aquaria, only for technical purposes)*

Schiff's Reagent
Dissolve 0.5 g of fuchsin in 500 mL of DI water. Decolorize solution by passing sulfur dioxide gas through the solution or add 9 g of sodium bisulfite and 20 mL of 2 M hydrochloric acid to the fuchsin solution. *(test for aldehydes)*

Schweitzer's Reagent
Boil a solution of 5 g of copper(II) sulfate pentahydrate in 100 mL of DI water and slowly add 2 M sodium hydroxide solution until precipitation is complete. Filter the copper oxide precipitate, wash with water then dissolve in the minimum volume of 4 M ammonium hydroxide. Also called ammoniacal copper oxide solution. *(reagent for dissolving cellulose)*

Sebacoyl Chloride/Hexane Solution
Mix 4 mL of sebacoyl chloride with 96 mL of hexanes. *(nylon demonstration)*

Starch Solution
1% aqueous: Make a smooth paste with 10 g of soluble starch and DI water. Pour the starch paste into 1 L of boiling water while stirring. Cool to room temperature before use. Poor shelf life, always prepare fresh solution. An easier way to make a starch solution is to generously spray ordinary spray starch (the type used for ironing) into DI water. Make fresh. *(indicator for iodine)*

Sudan III
Warm 73.5 mL of 95% ethyl alcohol in a warm water bath. Add 0.5 g of sudan III and stir. Add 75 °C DI water to just below the 100-mL mark. Stir and cool to room temperature then dilute to 100 mL with DI water. Filter if necessary. *(biological stain for fats and lipids)*

Sudan IV
Warm 75 mL of 95% ethyl alcohol in a warm water bath. Add 0.5 g sudan IV and stir. Cool to room temperature then dilute to 100 mL with DI water. Filter if necessary. *(biological stain for fats and lipids)*

10X TBE Electrophoresis Buffer
Dissolve 108 g of Tris base [tris(hydroxymethyl) aminomethane], 55 g of boric acid and 7.5 g of EDTA, disodium salt in 800 mL of DI water, then dilute to 1 L. There is no need to sterilize the solution. If white clumps begin to precipitate in the solution, place the bottle in hot water until the clumps dissolve. Stored at room temperature. To use as a buffer, dilute 100-mL of 10X stock to 1 L with DI water.

10X TAE Electrophoresis Buffer
Dissolve 48.4 g of Tris base [tris(hydroxymethyl) aminomethane], 11.4 mL of glacial acetic acid (17.4 M) and 3.7 g of EDTA, disodium salt in 800 mL of DI water, then dilute to 1 L. There is no need to sterilize the solution. Stored at room temperature. To use as a buffer, dilute 100-mL of 10X stock to 1 L with DI water.

Thymol Blue
0.04% aqueous: Mix together 0.04 g of thymol blue and 50 mL of DI water. Add 5 mL of 0.01 M sodium hydroxide solution; stir until all the solid has dissolved. Dilute to 100 mL with DI water. *(pH indicator)*

Thymol Blue
0.04% aqueous: Dissolve 0.04 g of thymol blue, sodium salt in 75 mL of DI water, then dilute to 100 mL. *(pH indicator)*

Thymolphthalein
0.04% alcoholic: Dissolve 0.04 g of thymolphthalein in 75 mL of anhydrous ethyl alcohol, then dilute to 100 mL with anhydrous ethyl alcohol. *(pH indicator)*

Tollen's Reagent
Add 2–3 drops of 2 M sodium hydroxide solution to 5 mL of 0.2 M silver nitrate solution; add 2 M ammonium hydroxide solution dropwise until precipitate dissolves. Prepare and use this solution immediately; explosive fulminating silver will form if solution is allowed to stand for any period of time. *(test for aldehydes and reducing sugars)*

Toluidine Blue O
Mix 1 g of toluidine blue O and 0.5 mL of concentrated hydrochloric acid into a homogeneous paste. While stirring, gradually add the paste to 50 mL of DI water, then dilute to 100 mL of DI water. *(biological stain for bacteria)*

Universal Indicator
Add 0.18 g of methyl red and 0.36 g of phenolphthalein to 550 mL of 95% ethyl alcohol (C_2H_5OH); stir to dissolve. In a separate container, add 0.43 g of bromthymol blue to 200 mL of distilled water; stir to dissolve. Mix together the two solutions; dilute to 1 liter with distilled water. Add 1 M sodium hydroxide solution dropwise until the solution's color is dark green; stir. *(Use: pH indicator, pH 4 = red, pH 5 = orange, pH 6 = yellow, pH 7 = light green, pH 8 = green-blue, pH 9 = dark blue-green, pH 10 = purple)*

Winkler's Solution #1
Dissolve 480 g of manganese(II) sulfate tetrahydrate in 500 mL of DI water, then dilute to 1 L. *(determining dissolved oxygen)*

Winkler's Solution #2
Dissolve 500 g of sodium hydroxide and 135 g of sodium iodide in 700 mL of DI water, then dilute to 1 L. A large amount of heat is generated, place the mixing container in an ice water bath. Store in a plastic container. *(determining dissolved oxygen)*

Wright's Stain
Dissolve 2.5 g of Wright's stain in 5 mL of absolute methyl alcohol, then dilute to 100 mL with absolute methyl alcohol. Stir and filter if necessary. *(biological stain for blood)*

Note: DI water denotes either distilled or deionized water.

Laboratory Solutions for the Science Classroom

The Teacher's Handbook to Solution Preparation

Need a more complete guide on solution preparation? *Laboratory Solutions for the Science Classroom* has been the science teacher's No. 1 handbook for years. Includes explanations of basic concepts and vocabulary terms, detailed recipes of more than 300 commonly used solutions and practical solution-making techniques. Recipes cover biology (culture media and biological stains), chemistry and physical science solutions used in high schools. If you happen to come across a solution for which a recipe is not included, then the explanation section of the book will guide you through the steps of determining the correct procedure for making the solution. A must for all science teachers! Illustrated, appendices, glossary, index. 189 pages, 5¾" x 8¾", soft cover.

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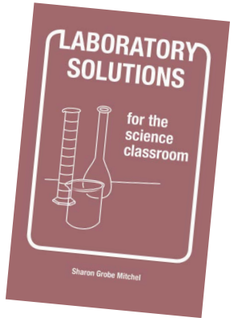


Suggestions for Taking a Chemical Inventory **in the School Science Department**

- **Have spill/breakage aids available.**
- **Make sure the room is well lighted.**
- **Plan before you start.**
- **Alert school administrators about the inventory.**
- **Use safe ladders.**
- **Wear appropriate clothing.**
- **Avoid involving students.**
- **Work slowly.**

We are sure that responsible science teachers and school administrators agree that it is necessary to know exactly what chemical substances are present on school premises and in what quantities. Such an inventory would serve many valuable purposes such as (but not limited to):

- To comply with regulatory requirements
- To make the school safer
- To efficiently use (and perhaps share) the existing inventory
- To rid the premises of excess/unused chemical substances
- To implement the storage of all remaining substances in compatible chemical families
- To isolate and safely store particularly hazardous substances
- To create and maintain a perpetual inventory of all chemical substances
- To identify substances (e.g., severe toxins, carcinogens) that should not be found on school premises and get rid of these materials
- To identify substances as a function of their specific hazardous character (e.g., flammables, acids, oxidizers) and provide their dedicated and approved storage

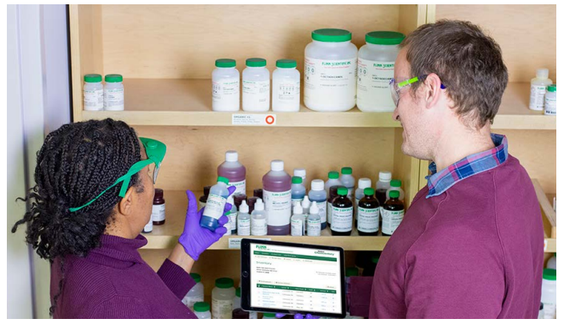
In our opinion, just plain old-fashioned "good sense" suggests that it is time for action! Action demands that you know what you have and how much of it you have. Once this inventory is accomplished, a great many benefits will follow.

It is very important to point out that laboratory chemicals should ***no longer be purchased like other routine school supplies!*** The normal routine of most schools is to acquire a year's supply of needed chemicals at one time along with other routine science supply needs. The result of this process is that dozens of chemical items, many in very large quantities, arrive at the school and are then stored in science storerooms never designed to handle such quantities and rarely equipped to meet even minimum standards of safe storage. We are sure your conventional wisdom says that the smaller the quantities of these materials found in schools at any given time, the smaller the problem.

We cannot emphasize strongly enough the need for science teachers, science department heads and, most particularly, school administrators and business managers to recognize the problems created by lumping hazardous chemicals into the buying routine. To continue to apply the same buying routine to hazards simply aggravates and perpetuates the problem. Those in the school with science backgrounds must educate the non-science-trained administrators about the severe problems created by continuing to buy hazardous chemicals in the same manner as they buy routine school supplies.

It can also accurately be stated that when a large school with many science teachers has no one in charge of managing the chemical storeroom, the problem is made more severe. When every science teacher or multiple science teachers are in charge of this matter—then, in fact, no one is in charge.

School districts with multiple school buildings also should give very serious consideration to establishing a central "chemical ordering committee." This committee could routinely see every chemical requisition. Their review would be aimed at completely eliminating or reducing the quantity of some substances purchased. No, we are not suggesting that science teachers be denied access to needed reagents. We are, however, suggesting that the matter be well managed. Who better to manage the problem than the knowledgeable users (i.e., the science teachers meeting as a committee).



It is common to find, among multiple school buildings, an excess of a chemical in Building A while the science teacher in Building B just placed an order for the very same chemical. Why can't inventories be shared with the goal of better systemwide chemical management? If the impediment to better, safer and more efficient substance management is the "established system" or the "established bureaucracy" then the "system" or the "bureaucracy" must be educated and its methods changed. An efficient method of chemical management in a science department or in a multiple-building school is to provide inventory-level information to all users and allow all users access to excess inventories. One building or department should not be allowed to rob another's inventory. However, excesses should be identified and shared. The science teacher who is a good substance or inventory manager should not be penalized to serve the poor manager in another department or building. Conventional wisdom suggests that excess substances can be better managed by sharing knowledge of their existence. For more efficient management of chemical supplies, a good inventory and communication is critical.

Once you have decided it is time to take an inventory, plan for the event using the Inventory Planning Checklist that follows on the next page. A very effective means of taking and temporarily recording your inventory is by using your phone or tablet as a recording device.

It is an absolute that you ***never undertake an inventory alone***. You must always have a teammate. The teammate is there to help you, to hold a ladder, to go for help or just to be there—but, in any case, you should never work alone. We urge against recruiting students. It is also an absolute that the right kind and type of fire extinguishers be in the room with you and immediately available for use.

Another absolute is that you are appropriately dressed and spill materials are present. In general, we assume you have done all the preplanning and all the plans have been implemented.

Record on paper or computer, the chemical name, bottle size, bottle type and approximate amount of chemical present. For example, a typical description might read, "one 5-lb bottle, glass, of acacia, about one-half full." You may opt to use Flinn Online Chemventory™, which is a cloud-based laboratory chemical inventory system that allows multiple users access to a single chemical inventory database

CHEMICAL INVENTORY continued on next page.

Chemical Inventory, continued

from multiple locations and devices. The program comes fully loaded with GHS pictograms, hazard codes and signal word information for more than 2,400 Flinn chemicals. You can build your inventory by selecting from a list of Flinn chemicals or add your own chemical information manually. You can build an inventory database for your school and invite other teachers, lab assistants and administrators to join for free. The program also includes a label printing feature to print GHS-compliant labels for any of the 2,400+ Flinn chemicals listed in the program. You also can take advantage of the chemical solution label printing options to easily keep track of all the solutions you prepare in your lab.

To the extent you can, you should avoid actually touching or moving bottles to take this inventory. If your shelves are loaded, you may have to remove some bottles in order to see the bottles at the rear of the shelf or cabinet. Try to avoid as much moving or transfer as possible.

It is unlikely that you will want to reorganize your shelves at this time since your primary goal is to determine what you have and how much of it you have. Once the inventory is complete and has been converted to hard copy then you can begin to think about the reorganization process. At this point focus on just discovering and recording what and how much you have. You really should not consider major reorganization until you know the "what and how much" since these facts may cause you to elect not to set shelf space aside for substances you wish to eliminate from your inventory. It is our experience that in an average school (if there is such a thing as an average school), four out of ten bottles on the shelves have not been used in the last five years and will not be used in the next five years. There is no need to dedicate shelf space to such excess substances.

If your shelves and cabinets are just loaded and a lot of movement of substances is required to inventory all the materials, then the task will require several hours. If however, most substances can be viewed and recorded with little bottle shifting or relocation then even a very large high school chemical stores facility will not require much more than about 2–2½ hours to record all of these substances and their pertinent information.

We recommend aquiring the Flinn Online Chemventory™. This system can be used to track and describe chemical information and on-hand amounts while also providing easy, electronic access to chemical information form on- and off-site locations.

CHEMICAL INVENTORY continued on next page.

QUESTIONS? CALL US AT
1-800-452-1261

Inventory **Planning Checklist**

- Who will be the team members to perform the inventory?
- How much time will you allow to perform this task?
- As materials are taken from the shelf (if you elect to do this at this time), where and how will they then be housed?
- Do you have the requisite safety items to protect yourselves during the process?
- Will this be simply an inventory of what substances you have, or will it be a major reorganization of the chemical stores facility?
- Are flashlights, ladders and other such devices available?
- Will the room be properly ventilated during the process?
- Will a means of communicating with the outside be available in case of a serious problem like spill, breakage or fire.
- How will you record the chemicals on a substance-by-substance basis?
- How will you handle unknowns or "mystery" substances as these are encountered?
- Will spill materials (e.g., sand, neutralizers) be available? If yes, which have you chosen?
- Will alternate containers (e.g., empty bottles, cans, bags) be available when a broken container is encountered?
- Is there a plastic broom, plastic dust pan and plastic receptacle available for cleanup?
- Have you made arrangements for the removal of unwanted substances or, if you want to isolate these materials, have you planned for temporary and safe storage methods while you examine your disposal options?
- Will a fume hood be available to very temporarily store a substance that, upon discovery, needs your immediate attention?
- Have you undertaken and completed as much storeroom housekeeping as possible prior to the inventory so you are not faced with obstacles that would lead to an accident?
- Have school authorities and maintenance people been alerted to this inventory undertaking?
- If you elect to do some disposal during the inventory process (we urge against this), are the reacting chemicals available?
- Have you arranged for the process to be free of interruptions that might distract you at a critical moment?
- Will the team members performing the inventory be wearing appropriate clothing?
- Will all sources of ignition be eliminated?
- Is it your plan to add some form of label or other kind of identification to each chemical container, and, if so, have you decided how this is to be done and do you have the means to do it available?
- Will you have a supply of replacement caps available for containers with bad closures? If you expect to transfer some substances to alternate containers, are some available?
- What will be done with the many bottles of solutions that have been prepared and stored for lab use over the past years? Will you include these in your inventory? How?
- If you expect to rearrange your chemical shelves during the process, are shelf labels available?
- Do you expect to identify substances by their hazardous character during the process? If yes, will you then house them (e.g., flammables, acids) in dedicated and approved cabinets? Are the cabinets now available? Is there sufficient space in the existing cabinets?
- Will the method you select to record this inventory allow you, if you elect to do so, to perpetually maintain the inventory?
- Will you have tape or an adhesive of some kind available to affix loose labels? Will you have blank labels available to place on currently unlabeled materials that you can identify with accuracy?

Chemical Inventory, continued

Next assign compatible chemical family designations and hazard data to each listing. Our online chemical inventory system has established 15 alpha designations to identify hazards. You may wish to use this same system to code your list. The designations follow.

Flinn Hazard Caution Codes

A — Flammable
B — Volatile
C — Toxic
D — Strong oxidizer or reducer
E — Carcinogenic
F — Produces peroxides
G — Skin and/or eye irritant
H — Contains harmful impurities
I — Unpredictable explosive
J — Harmful dust or vapors
K — Avoid contact with water
L — Avoid contact with air
M — Corrosive
N — Allergen
O — Avoid contact with organic material

If you do not know either the hazardous character or compatible chemical family of a substance, you need look no further than the individual listings of any chemical in the *Flinn Scientific Catalog/Reference Manual*.

Your next step would be to decide what stays and what goes in this total inventory. We urge you to be ruthless in ridding your premises of these unused and unneeded chemicals. In fact, when you have made the decision about ridding yourself of many substances, then consider getting those items off your shelf first. Do not simply acquire some cartons and pile bottle upon bottle into cartons and create a new problem. Rather, use your conventional wisdom and ask yourself if the item is hazardous and then investigate its hazardous character.

Be able to call for help in the event help is needed.

Should a chemical be physically isolated? Let's assume you find a 500-gram bottle of aluminum chloride, anhydrous, and you wish to rid yourself of this substance. You do not know how to achieve this, but you want it off the shelf and yet protected and safe for later disposition. Place the bottle in three thicknesses of baggies. You can get baggies at your local grocery store. Flinn has heavy-duty plastic bags called *Chem-Saf*™ Bags for this purpose. You will find *Chem-Saf*™ Bags listed on page 653 in this catalog/reference manual. Next, acquire some clean, never-used, one-quart and one-gallon paint cans. Flinn has such containers called *Saf-Stor*™ Cans. These are also listed on page 653 in this catalog/reference manual. You can acquire similar cans (less heavy duty) at a local paint or hardware store.

Now line the bottom of the can with just enough vermiculite or cat litter (cat litter is bentonite) to cushion the plastic bag-enclosed bottle. Place the plastic bag-enclosed bottle in the center of the can. Fill the remaining empty void of the can with vermiculite or cat litter. Place the friction lid on the can and label the outside of the can with the chemical formula of the substance contained therein. By using the chemical formula rather than the full name, you can thwart the potential vandal intent upon securing or using a hazardous chemical. The vandal simply will not be able to read the formula.

You have now provided a secure container for this unwanted substance. You may now assign an area in the storeroom where such hazards will be safe until you investigate and ultimately exercise your disposal or removal options. You will find that plastic bags and cans can be among your best friends for isolating and containing hazards during your investigation.

The cans will serve to protect against breakage and even act as a miniature fire cabinet to prevent these hazards from being directly involved in a conflagration.

Substances that remain on your shelves can now be reorganized into their compatible chemical families. We urge that you review all the details of appropriate and safe storage in the section of this catalog/reference manual dedicated to that subject.

Avoid distractions.

For the first time, you know exactly the substances and their quantities in your chemical stores area. It is from this base of knowledge that you can begin to manage this matter of chemicals on school premises. You needed to take this first, important step. You may need further help and advice. If you do, call Flinn.

CHEMICAL INVENTORY continued on next page.

Chemical Inventory, continued

FLINN COMPATIBLE **CHEMICAL FAMILY CODES**

When you assign compatible chemical family data, you may wish to use the system created by Flinn. The family designations are listed here and explained in more detail on the following pages. Family designations for individual chemicals are found in the individual chemical listings of this catalog/reference manual.

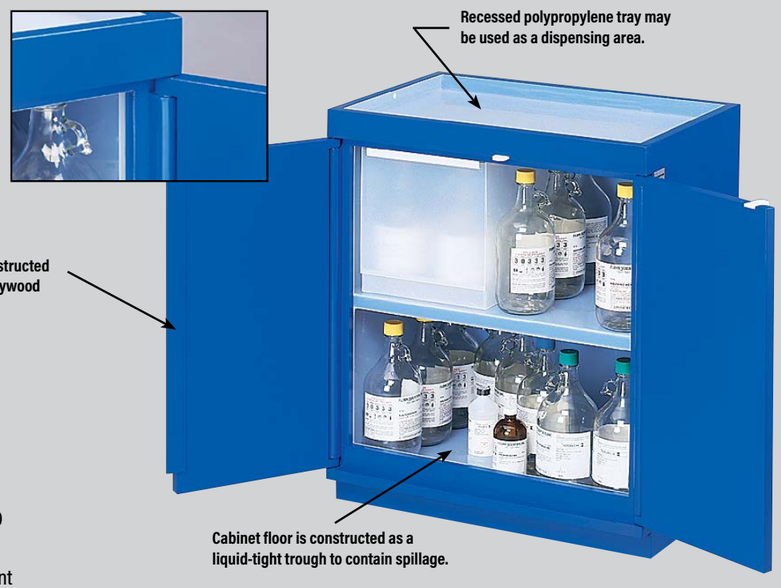
Flinn Organic Compatible Family Codes

01 – Acids, Amino Acids, Anhydrides, Peracids
02 – Alcohols, Glycols, Sugars, Amines, Amides, Imines, Imides
03 – Hydrocarbons, Esters, Aldehydes, Oils
04 – Ethers, Ketones, Halogenated Hydrocarbons
05 – Epoxy Compounds, Isocyanates
06 – Peroxides, Hydroperoxides
07 – Sulfides, Polysulfides, Sulfoxides, Nitriles
08 – Phenols, Cresols
09 – Dyes, Stains, Indicators
0M – Miscellaneous

Flinn Inorganic Compatible Family Codes

I1 – Metals, Hydrides
I2 – Acetates, Halides, Iodides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens, Oxalates, Phthalates, Oleates
I3 – Amides, Nitrates (except Ammonium Nitrate), Nitrites, Azides
I4 – Hydroxides, Oxides, Silicates, Carbonates, Carbon
I5 – Sulfides, Selenides, Phosphides, Carbides, Nitrides
I6 – Chlorates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, Perchloric Acid, Peroxides, Hydrogen Peroxide
I7 – Arsenates, Cyanides, Cyanates
I8 – Borates, Chromates, Manganates, Permanganates, Molybdates, Vanadates
I9 – Acids (except Nitric) (Nitric Acid is isolated and stored by itself.)
I10 – Sulfur, Phosphorus, Arsenic, Phosphorous Pentoxide
IM – Miscellaneous

Here's the Last Acid Cabinet **You'll Ever Need!**



DIMENSIONS:

Exterior:
36½" H x 31" W x 20" D

Interior:
28½" H x 29" W x 17¼" D

Bottle Capacity:
30 x 5 Pints or 90 x 1 Pint

Catalog No.	Description	Price/Each
SE8041	Flinn Acid Cabinet. Interior partially lined with polypropylene.	$ 1250.00
SE8051	Flinn Acid Cabinet. Interior fully lined with polypropylene.	1450.00
SE8071	Nitric Acid Compartment. Polypropylene.	145.01

Flinn Acid Cabinets will not rust or corrode. Many companies promise corrosion resistance; we'll guarantee it. How? Simple—we don't use metal hardware or hinges. We use only wood and plastic in our construction; therefore, there is no rust or corrosion. Our unique design and unsurpassed quality will give you an outstanding cabinet both now and for many years to come.

See free video at flinnsci.com.

Suggested Sequence of Steps to More Safely **Organize Your School's Chemical Stores Area**

1 Take an inventory of all the chemicals in your school. You will never know the extent of your problem until you know exactly what you have. Record the inventory. You may want to consider the purchase of the Flinn Online Chemventory™ system to facilitate this task.

2 Decide what products you will need for the next year (at best, two years). Ruthlessly rid yourselves of the remaining the accumulated materials.

3 Reorganize the remaining products into their compatible chemical families (see our Suggested Chemical Storage Pattern on pages 726–730). The actual sequence of compatible families on your shelves is not critical. What is important is to keep the compatible families separate and to keep the organic and inorganic families as far apart as possible. The Suggested Shelf Storage Pattern shown on pages 726–730 is only one suggested sequence you can use. If shelf space is a problem, you are permitted to place more than one compatible family on a shelf. Make sure you either have a physical divider or leave a 3" space between each family.

Hundreds of teachers who have reorganized their shelves, using these patterns, tell us products are easier to find versus the alphabetical system previously used. When you reorganize, you may need some estimate of the percentage of shelf space each family might occupy. If yours is a "typical" high school, the following profile may be a helpful guide.

Inorganic Families

Families	Percentage of Shelf Space Occupied	Families	Percentage of Shelf Space Occupied
Acids (Inorganic 9)	Store away from all other items. Store in a dedicated acid cabinet. Store nitric acid away from all other materials.	Sulfides, etc. (Inorganic 5)	Less than 1%
Metals, etc. (Inorganic 1)	Less than 5%	Chlorates, Perchlorates, etc. (Inorganic 6)	5+%
Halides, Sulfates, Phosphates, Acetates, etc. (Inorganic 2)	Could be 35–40% of available space. This is usually the largest family.	Arsenates, etc. (Inorganic 7)	Less than 1%
Nitrates, etc. (Inorganic 3)	Approximately 8–10%	Borates, Chromates, etc. (Inorganic 8)	Less than 1%
Hydroxides, Oxides, etc. (Inorganic 4)	Approximately 10%	Sulfur, Phosphorus, etc. (Inorganic 10)	Approximately 3%

4 **Organic Families**

Organic acids (Organic 1) will probably occupy about 5+% of your organic shelf space except for acetic acid, which should be stored with the inorganic acids (e.g., hydrochloric) in a dedicated acid cabinet. Keep acetic acid *away* from nitric acid. If your school is "typical," the remainder of your organic materials may occupy about 15–20% of your total shelf space. You should store all flammable organics in a dedicated flammables cabinet.

5 **Other Materials**

There may be some very large space consumers in 2-kilogram (5-lb.) containers (e.g., calcium chloride, calcium hydroxide). Certainly you may wish to extend family storage in a separate location for such large volumes of large packages.

6 **Congratulations! You have now reorganized your chemical stores facility to:**

- Store compatible products together.
- Separate acids into dedicated storage.
- Separate flammables into dedicated storage.
- Lock up all poisons.
- Record all inventory.
- Rid yourselves of excess materials.

YOU NOW HAVE A SAFER FACILITY!

Suggested Chemical **Storage Pattern**

Storage of laboratory chemicals presents an ongoing safety hazard for school science departments. There are many chemicals that are incompatible with each other. The common method of storing these products in alphabetical order sometimes results in incompatible neighbors. For example, storing strong oxidizing materials next to organic chemicals can present a hazard.

A possible solution is to separate chemicals into their organic and inorganic families and then to further divide the materials into related and compatible families. Following is a list of compatible families. On the next page, you will find this family arrangement pictured as shelf areas in your chemical stores area. The pictured shelf arrangement will easily enable you to rearrange your inventory into a safer and more compatible environment.

Inorganic

1. Metals, Hydrides
2. Acetates, Halides, Iodides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens, Oxalates, Phthalates, Oleates
3. Amides, Nitrates (except Ammonium Nitrate), Nitrites, Azides
4. Hydroxides, Oxides, Silicates, Carbonates, Carbon
5. Sulfides, Selenides, Phosphides, Carbides, Nitrides
6. Chlorates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, Perchloric Acid, Peroxides, Hydrogen Peroxide
7. Arsenates, Cyanides, Cyanates
8. Borates, Chromates, Manganates, Permanganates, Molybdates, Vanadates
9. Acids (except Nitric) (Nitric Acid is isolated and stored by itself.)
10. Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide
11. Inorganic miscellaneous

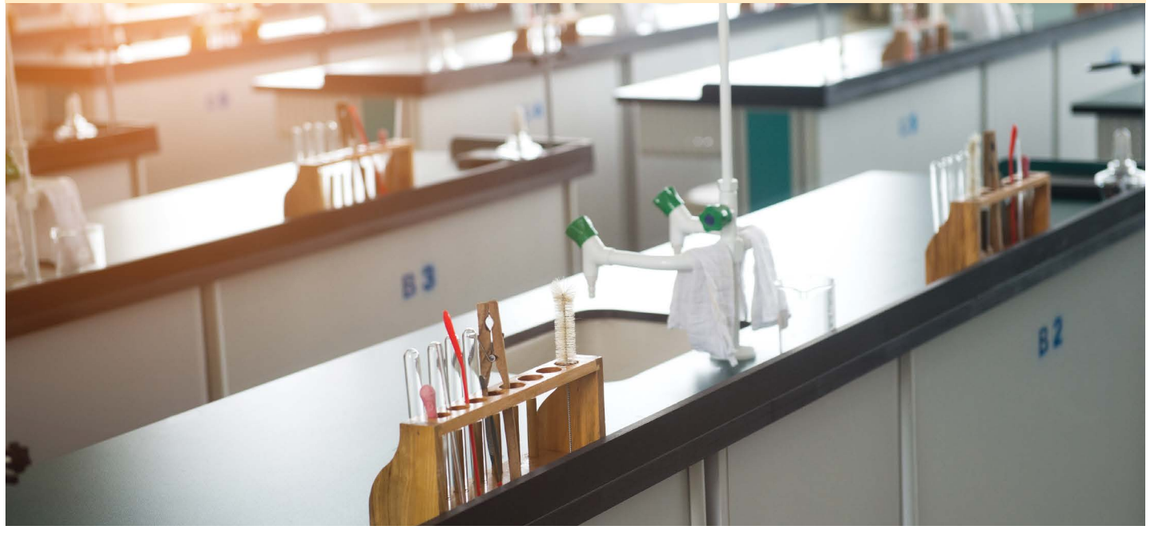
Organic

1. Acids, Amino Acids, Anhydrides, Peracids
2. Alcohols, Glycols, Sugars, Amines, Amides, Imines, Imides
3. Hydrocarbons, Esters, Aldehydes, Oils
4. Ethers, Ketones, Halogenated Hydrocarbons
5. Epoxy Compounds, Isocyanates
6. Peroxides, Hydroperoxides
7. Sulfides, Polysulfides, Sulfoxides, Nitriles
8. Phenols, Cresols
9. Dyes, Stains, Indicators
10. Organic miscellaneous

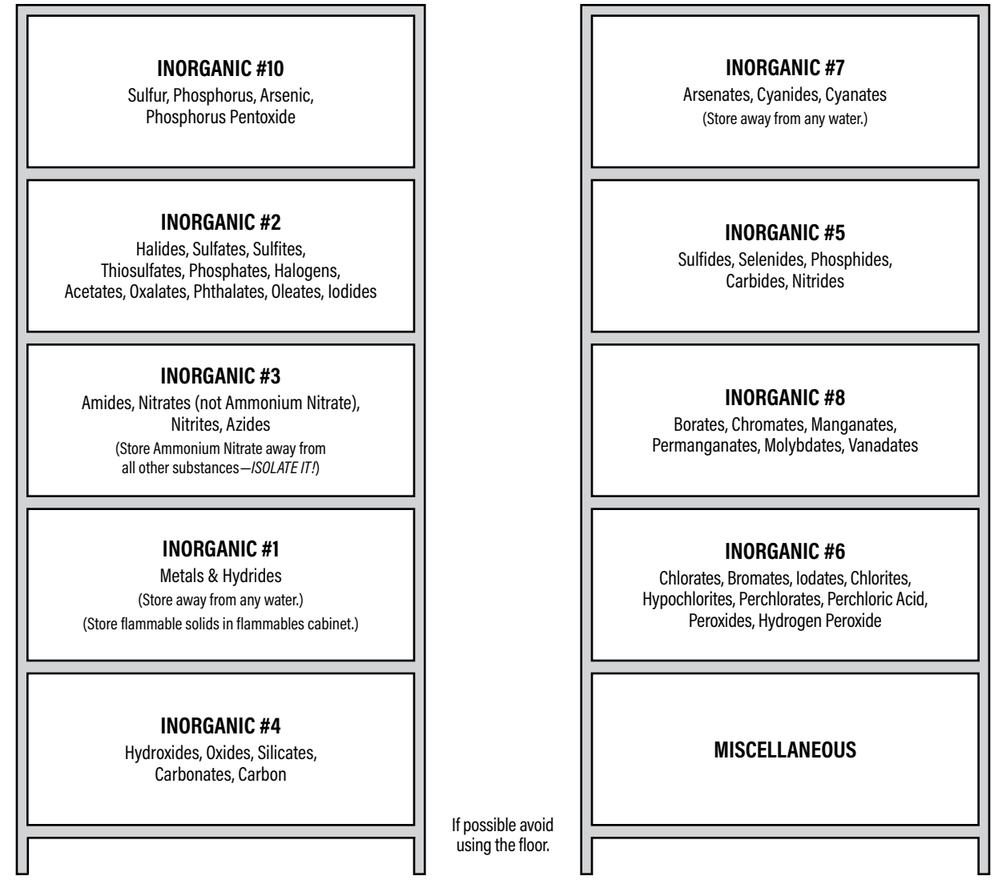
NOTE: If you store volatile materials (e.g., ether, hydrocarbons) in a refrigerator, the refrigerator must be explosion-proof. The thermostat switch or light switch in a standard refrigerator may spark and set off the volatile fumes inside and thus cause an explosion.

This list is not complete and is intended only to cover the materials possibly found in an average school situation. This is not the only method of arranging these materials and is only offered as a suggestion.

See the next few pages for detailed inventory and storage steps you might follow to vastly improve the safety profile of your chemical storage.



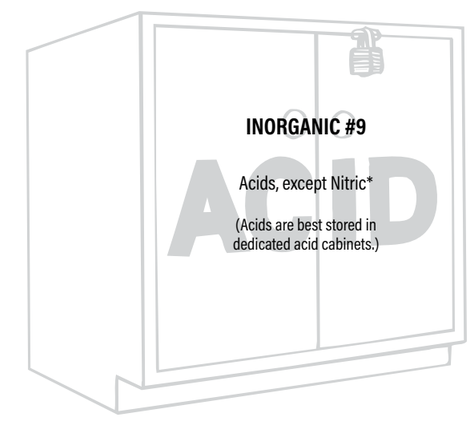
SUGGESTED SHELF STORAGE PATTERN—**INORGANIC**



Storage Suggestions

1. Avoid storing chemicals on the floor (even temporarily).
2. Do not use the top shelf for chemical storage.
3. Do not store chemicals above eye level.
4. Firmly secure shelf assemblies to walls. Avoid island shelf assemblies.
5. Provide anti-roll-off lips on all shelves (Catalog No. SE1069).
6. Ideally, shelving assemblies should be of wood construction.
7. Avoid adjustable metal shelf supports and clips. It is better to use fixed, wooden supports.
8. Store acids in a dedicated acid cabinet. Store nitric acid in the same cabinet **only** if isolated from other acids. Store both inorganic and some organic acids in the acid cabinet.
9. Store flammables in a dedicated flammables cabinet.
10. Store severe poisons in a dedicated poisons cabinet.

OTHER STORAGE SUGGESTIONS ARE CONTAINED THROUGHOUT THIS CATALOG/REFERENCE MANUAL.



*Store nitric acid away from other acids unless your acid cabinet provides a separate compartment for nitric acid.

SUGGESTED SHELF STORAGE PATTERN—**ORGANIC**

ORGANIC #2
Alcohols, Glycols, Sugars, Amines, Amides, Imines, Imides
(Store flammables in a dedicated cabinet.)

ORGANIC #3
Hydrocarbons, Oils, Esters, Aldehydes
(Store flammables in a dedicated cabinet.)

ORGANIC #4
Ethers, Ketones, Halogenated Hydrocarbons, Ethylene Oxide
(Store flammables in a dedicated cabinet.)

ORGANIC #5
Epoxy Compounds, Isocyanates

ORGANIC #7
Sulfides, Polysulfides

If possible avoid using the floor.

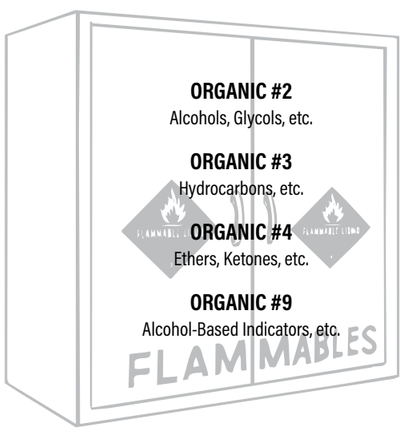
ORGANIC #8
Phenols, Cresols

ORGANIC #6
Peroxides, Hydroperoxides

ORGANIC #1
Acids, Amino Acids, Anhydrides, Peracids
(Store **certain** organic acids in acid cabinet.)

ORGANIC #9
Dyes, Stains, Indicators
(Store alcohol-based solutions in flammables cabinet.)

MISCELLANEOUS



HOW TO

Maximize Storage Space

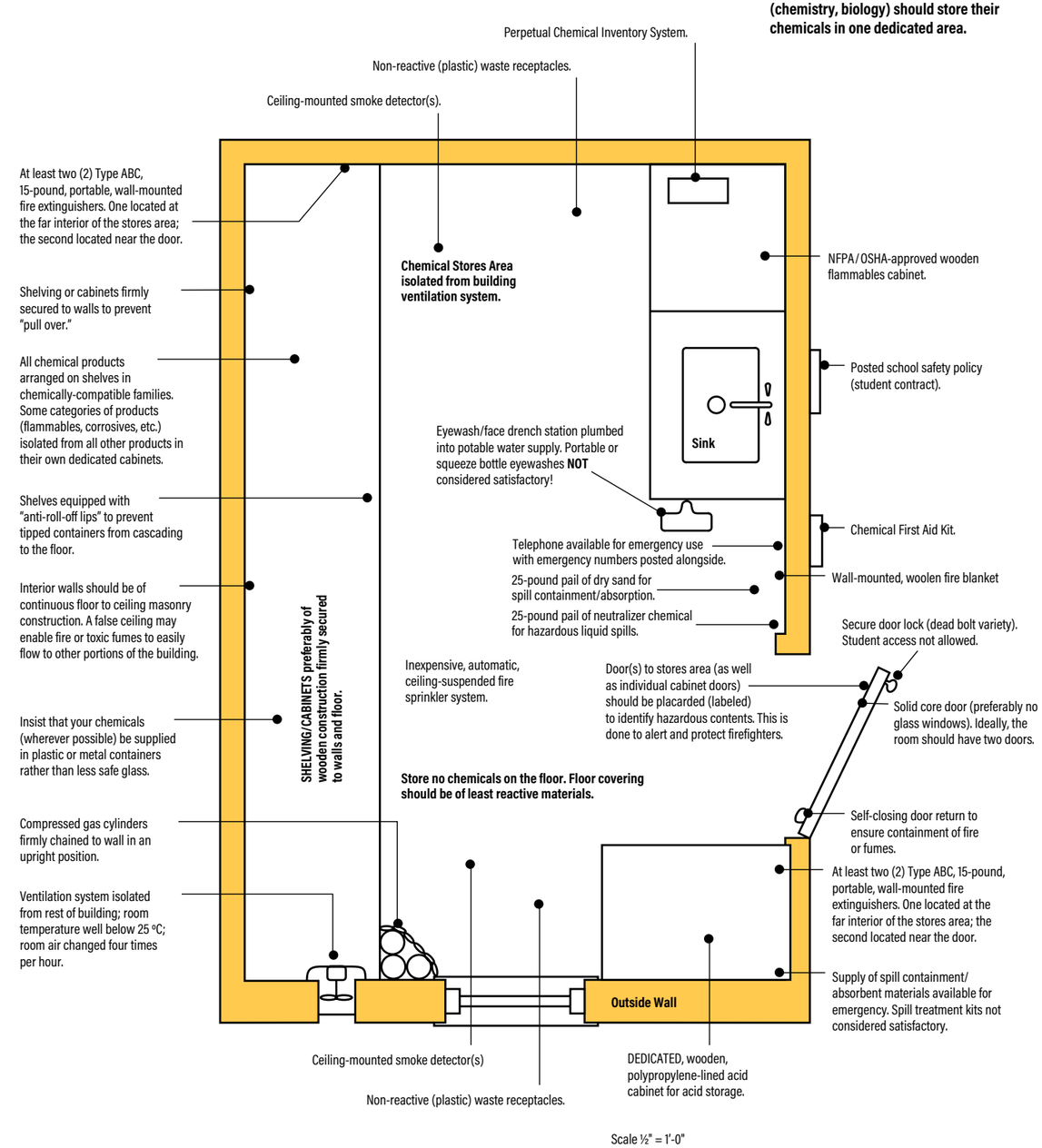
If shelf space is a problem, you are permitted to place more than one compatible chemical family on a shelf. Make sure you either have a physical divider or leave a 3" space between each family. This will maximize your tight shelf space while keeping each compatible chemical family separate from one another.

See page 730 for complete instructions on organizing your chemical stores area.

MODEL CHEMICAL STORES AREA

Please compare your facility to this model.

- **Never store chemicals in a fume hood.**
- **No chemicals routinely stored in classrooms.**
- **VARIOUS SCIENCE DEPARTMENTS (chemistry, biology) should store their chemicals in one dedicated area.**



Scale ½" = 1'-0"

MANY REASONS WHY WE ENCOURAGE YOU
NOT TO STORE CHEMICALS IN ALPHABETICAL ORDER

IF PRODUCTS ARE STORED TOGETHER	POSSIBLE REACTIONS
Acetic acid + acetaldehyde	**Small amounts of acetic acid will cause the acetaldehyde to polymerize, releasing great amounts of heat.**
Acetic anhydride + acetaldehyde	**Reaction can be violently explosive.**
Aluminum metal + ammonium nitrate	**Potentially explosive results.**
Aluminum metal powder + antimony trichloride	**Aluminum metal burns in the presence of antimony trichloride.**
Aluminum metal + any bromate, chlorate or iodate	**Finely divided aluminum metal in contact with a bromate, chlorate or iodate can be easily detonated by heat, shock or friction.**
Aluminum + bromine vapor	**Aluminum foil reacts with bromine vapor at room temperature and incandesces.**
Aluminum chloride, anhydrous	**$AlCl_3$, anhydrous, is constantly generating hydrochloric acid. After long storage, tightly closed containers have been known to explode when opened.**
Ammonia vapor + bromine vapor	**Unstable nitrogen tribromide is formed and explosion may result.**
Ammonium nitrate + acetic acid	**A mixture may result in ignition, especially if the acetic acid is concentrated.**
Antimony + bromine	**Antimony is spontaneously flammable in the presence of any halogen vapor.**
Arsenic + any bromate, chlorate or iodate	**A potentially explosive combination results if detonated by heat, shock or friction.**
Barium + carbon tetrachloride	**A violent reaction may occur.**
Calcium hypochlorite + charcoal	**A mixture can result in an explosion if heated.**
Carbon + any bromate, chlorate or iodate	**A potentially explosive combination results if detonated by heat, shock or friction.**
Carbon disulfide + aluminum	**Finely divided aluminum will spontaneously burst into flame in the presence of carbon disulfide.**
Chromium trioxide and glycerol	**Violent reaction may cause mixture to ignite.**
Copper + bromate, chlorate or iodate	**A potentially explosive combination results if detonated by heat, shock or friction.**
Hydrogen peroxide (6% or more) + iron(II) sulfide	**A vigorous, highly exothermic reaction results.**
Hydrogen peroxide (6% or more) + lead(II) or (IV) oxide	**Violent, possibly explosive reaction results.**
Lead sulfide + hydrogen peroxide (6% or more)	**Vigorous, potentially explosive reaction results.**
Magnesium hydroxide + maleic anhydride	**Potentially explosive reaction results.**
Mercury(II) nitrate + methyl alcohol	**May form mercury fulminate—an explosive.**
Mercury(II) oxide + magnesium metal	**An explosion may result if heated.**
Mercury(II) oxide + phosphorus	**Percussion may ignite this mixture.**
Nitric acid + magnesium metal powder	**Will react with explosive force.**
Nitric acid + phosphorus	**Phosphorus will burn spontaneously in the presence of nitric acid.**
Potassium cyanide + potassium nitrite	**A potentially explosive mixture results if heated.**
Silver metal + tartaric acid	**An explosive mixture results.**
Silver oxide + sulfur	**A potentially explosive mixture results.**
Sodium + sulfur	**Under the right conditions the reaction can proceed with explosive violence.**
Sodium nitrate + sodium thiosulfate	**A mixture of dry materials can result in explosion.**
Tin(IV) chloride + turpentine	**A flame-producing, exothermic reaction results.**

Review of Chemical **Disposal Procedures**

Responsible management of the chemical resources of school science labs encompasses best practices for the purchase, storage, use and disposal of chemicals. It is a shared responsibility of the administration, faculty and staff. Chemical disposal procedures require compliance with a variety of federal, state and local laws and regulations and are therefore a particular challenge for many science departments.

The Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) is the key law dealing with the identification, management and disposal of hazardous waste. All institutions are required to have a policy for identifying hazardous waste and complying with the requirements of RCRA, which was enacted in 1976. The overarching goals of the law are to reduce the amount and toxicity of hazardous waste and thus protect human health and the environment. In writing the regulations to ensure that the goals of RCRA are achieved, the Environmental Protection Agency (EPA) also has the mandate to promote methods to minimize the amount of hazardous waste and reduce its environmental impact. These methods include source reduction, reuse and recycling of wastes and chemical treatment that will eliminate hazardous waste characteristics.

Knowing Your RCRA Status and Requirements

In most cases, authority for implementing and enforcing the law has been delegated to individual states that have adopted the RCRA guidelines. Some states may be more restrictive or impose additional conditions than federal guidelines require. The Federal EPA recognizes three classes of hazardous waste generators based on the amount and kinds of hazardous waste generated in one month. The storage and reporting regulations become increasingly more stringent as the amount of hazardous waste increases. Schools that generate less than 100 kg (220 lbs) of hazardous waste per month—and no more than 1 kg of acutely hazardous waste in any month—would fall into the least regulated "conditionally exempt small quantity generator" class. The EPA defines hazardous waste as a subset of solid waste, where solid waste is anything that will be discarded or may enter the environment—by burning, for example. (It's confusing, but the term solid waste thus includes solids, liquids or gases!) Obviously, all schools and other institutions produce solid waste. Regardless of their RCRA status, all schools are required to determine which types of solid waste must be classified as hazardous waste. (The definitions for these types of waste are summarized in the following sections.)

Identifying Hazardous Waste

The first step in managing chemical disposal is identifying which discarded chemicals, as well as chemical reaction mixtures or byproducts that will not be reused, must be considered hazardous waste. There are two broad categories of hazardous waste—characteristic wastes and listed wastes. *Characteristic wastes* have one or more of the following properties:

- *Ignitable* wastes include flammable or combustible liquids (flash point <140 °F) as well as flammable compressed gases and solid oxidizers. Organic solvents, such as acetone or toluene, compressed gases, such as hydrogen, and solid ammonium nitrate are examples of ignitable wastes.
- *Corrosive* wastes are acidic or basic solutions that have a pH <2 or >12.5, respectively.
- *Reactive* wastes are substances that react violently with air or water, are capable of detonation or can generate toxic gases under relatively neutral conditions. Examples include the alkali metals sodium and potassium, diethyl ether and other peroxide-forming organic compounds and cyanides or sulfides.
- *Toxic* chemical wastes are substances that, if disposed in a landfill, are capable of leaching threshold amounts of specific chemicals into groundwater. There are 40 substances in this category (also known as toxicity characteristic wastes). Although many of the substances on this list are pesticides, the list includes common heavy metals, including lead, barium and silver.

There are four categories of *listed wastes*. Two categories include chemical byproducts from manufacturing processes and do not generally apply to schools. The other two categories, designated by the codes P and U, identify by name specific discarded commercial chemical products. All academic institutions should be aware of the chemicals on the P- (acutely toxic) and U- (toxic) lists. The P-listed, or *acutely toxic,* wastes are especially important because any school generating more than 1 kg (2.2 pounds or approximately one quart of liquid) of acutely hazardous waste per month will be subject to the most stringent generator requirements for listing, storing and reporting all their hazardous waste. Most institutions do not use many P-list chemicals. The exceptions, which some schools might use, are sodium cyanide, potassium cyanide, arsenic trioxide, sodium azide, ammonium vanadate and carbon disulfide. Recall that listed wastes refer to *discarded* or unused commercial chemical products where the chemical is the sole active ingredient. Make sure your school has effective chemical purchasing and inventory controls in place if you use P-listed chemicals in your science labs. This will prevent the school from accumulating excess chemicals that must be discarded.

Treating Chemicals in the Lab

The EPA encourages all waste generators, including academic institutions and laboratories, to minimize the amount of hazardous waste. Treating materials in the lab to reduce or eliminate chemical and physical hazards is one strategy for accomplishing this goal. Chemicals or chemical byproducts that are stored in the lab or remain in the lab after a lab activity is finished are not generally regulated as solid waste. The treatment of hazardous waste without a permit is generally not allowed. To avoid restrictions on treating hazardous waste, **always incorporate treatment or disposal of excess reagents or chemical byproducts from a chemical reaction into the lab procedure itself.** The Flinn Suggested Disposal Methods described on pages 736–753 frequently may be used to treat chemicals and eliminate potential hazards. Before undertaking any of these methods, it is important to read, review and understand the general principles and guidelines governing the disposal of laboratory chemicals:

- Check all federal, state and local guidelines that may apply.
- All procedures should be carried out by skilled and trained personnel who are familiar with the physical and chemical properties of the chemicals and understand the procedure.
- Observe all safety precautions, including the requirements for personal protective equipment.
- Carry out all reactions that may generate gases in the hood.
- Provide secondary containment to protect against spills.
- Consult current Safety Data Sheets for storage, handling and disposal information.
- Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

Examples of generally allowed chemical treatment methods include neutralization of acids and bases (Flinn Suggested Disposal Methods #24a, #24b and #10, respectively); redox reactions for oxidizing agents and reducing agents (Flinn Suggested Disposal Methods #12a and #12b); and precipitation reactions for metals (Flinn Suggested Disposal Methods #11 and #27h).

As an example of this strategy, some experiments or demonstrations, such as the iodine clock reaction, may produce small amounts of iodine as a byproduct. Incorporate reduction of the iodine, an oxidizer, at the conclusion of the experiment. (Halogens may be reduced with sodium thiosulfate according to Flinn Suggested Disposal Method #12a.) In reviewing this treatment method, make sure you know the balanced chemical equation so the appropriate molar excess of reducing agent, as well as any acid or base needed for the reaction, will be used.

QUESTIONS? CALL US AT
1-800-452-1261

REVIEW OF CHEMICAL DISPOSAL PROCEDURES continued on next page.

Review of Chemical Disposal Procedures, continued

Reducing the Amount and Toxicity of Hazardous Waste

Not all potentially hazardous waste must be shipped off-site for treatment or disposal. EPA and many states provide several regulatory exclusions that allow generators to treat hazardous waste without a permit as part of a broader mandate to further waste reduction efforts. In its publication "Little Known but Allowable Ways to Deal with Hazardous Waste," published in 2000, the EPA describes five strategies for minimizing hazardous waste. These include the domestic sewage exclusion, elementary neutralization, recycling, treatment in accumulation containers and burning in small boilers. Recall that each state sets its own requirements for compliance with RCRA regulations. Requirements cannot be less strict than federal law, but states may impose more limitations than federal law. Thus 28 states allow treatment in accumulation containers, two prohibit it, and the others impose some conditions or restrictions on treatment methods. (A complete state-by-state listing of all allowable waste reduction strategies can be found in the Appendix to the EPA publication cited.)

Source reduction, or pollution prevention, is the preferred method for reducing the environmental burden of hazardous wastes. Materials also may be reclaimed by processing them to recover useful products. When source reduction and reuse or recycling are not feasible, waste may be treated to reduce its volume and toxicity. EPA allows drain disposal of even hazardous wastes via the "domestic sewage exclusion" provided that amounts and chemicals are in compliance with all wastewater standards and discharge limits imposed by publicly owned water treatment works. Among the allowed chemical treatments are elementary neutralization of acids and bases, precipitating metals from solution to obtain insoluble salts and oxidation–reduction reactions. Treatment residues may still require management as a hazardous waste, and residues destined for land disposal are subject to land disposal restriction standards. **Never dispose of chemicals in a septic system or storm sewer.** Make sure chemicals will not react with piping systems, and do not specifically rely on dilution to reduce the reactivity of chemicals or render them nonhazardous.

Licensed Hazardous Waste Disposal

Some chemicals always will require licensed hazardous waste disposal. These include toxic heavy metal salts and their solutions, including mercury, lead, cadmium and chromium; arsenic and its compounds; halogenated organic solvents, such as methylene chloride, chloroform, trichloroethylene or perchloroethylene; and various pesticides.

Summary

Most schools and many small colleges will fall into the least regulated "conditionally exempt small quantity generator" class for complying with EPA regulations regarding the storage and disposal of hazardous waste; however, it is important to know your status. It is the responsibility of every school to identify all types of hazardous waste that they generate—whether characteristic wastes or listed wastes. An accurate and up-to-date chemical inventory is the most effective means of keeping track of all chemicals and thus preventing the accumulation of unused chemicals that will need to be discarded. This is especially important for discarded chemicals that would be designated as P-list, or acutely toxic, hazardous waste. Of the more than 2,400 chemicals that Flinn Scientific sells, only six are on the P-list. Laboratory chemicals or chemical byproducts are not generally considered to be waste until they have left the lab. To avoid restrictions on treating hazardous waste, always incorporate treatment of excess chemicals or chemical byproducts from a lab activity into the lab procedure itself. Please consult this *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. In its effort to reduce the amount and toxicity of hazardous waste, the EPA provides several exclusions for the treatment of hazardous waste without a permit. However, not all states allow all of these procedures. Among the generally allowed treatment methods are acid–base neutralization reactions, oxidation–reduction reactions and precipitating metals to obtain insoluble salts. Some chemicals always will require licensed hazardous waste disposal. Please call or email Flinn Scientific if you have any questions or if we can offer additional assistance.

Review of Chemical Disposal Procedures

The administration, faculty and staff share responsibility for minimizing the amount of hazardous waste and disposing of those wastes in a way that safeguards human health, protects the environment and complies with all relevant environmental laws and regulations.

It is suggested that regular safety meetings are conducted. The discussion period will vary depending on the issues that need to be addressed.

It is important to keep a copy of safety training notes and a signed attendance sheet to verify that regular safety training meetings were held. The sign-up sheet is almost as important as the training notes and is usually the first thing that is requested and reviewed by regulatory inspectors. A copy of the sign-up sheet that we suggest using may be found at www.flinnsci.com/forms/signup.aspx.

References

1. "Hazardous Waste Management for School Laboratories and Classrooms," EPA Publication 908-F-06-001, February 2006. Available online (accessed August 2015)
2. "Chemical Management Resource Guide for School Administrators," EPA Publication 747-R-06-002, December 2006. Available online (accessed August 2015)
3. "Little Known but Allowable Ways to Deal with Hazardous Waste," EPA Publication 233-B-00-002, May 2000. Available online (accessed August 2015)
4. ACS Task Force on Laboratory Waste Management; *Laboratory Waste Management: A Guidebook;* American Chemical Society: Washington, DC (2012).
5. Margaret-Ann Armour, *Hazardous Laboratory Chemicals Disposal Guide,* Third Edition; CRC Press, Lewis Publishers: Boca Raton, FL (2003).
6. National Research Council; *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards;* National Academies Press: Washington, D.C. (2011).

16 Steps to Minimize **Chemical Disposal**

Smart, Inexpensive Practices to Reduce Hazardous Waste

The single largest chemical problem facing most academic institutions today is chemical disposal. Purchasing chemicals in large package sizes, poor chemical inventory management, faculty and staff turnover and changes in the curriculum are just a few of the many reasons why your school may have a chemical disposal problem. Every school, college and university needs a plan to minimize future laboratory chemical/disposal issues. Chemical disposal is a necessary part of any chemical laboratory activity. The following 16 steps will help reduce the amount of chemicals that need to be disposed and make the disposal process easier to manage.

1. **Maintain an up-to-date inventory of your chemicals.**
   Maintaining a good chemical inventory will eliminate buying excess or unneeded chemicals.
2. **Purchase chemicals carefully.**
   Careful purchasing is the first step in decreasing the amount of unwanted chemicals and subsequent chemical disposal. To reduce unwanted chemicals, purchase smaller size packages of chemicals, only what is needed for the next 1 to 3 years and only from chemical suppliers that will guarantee fresh chemicals. If you only need a dilute solution of a chemical, buy the solution and not a large bottle of the solid. Buying chemicals in bulk to save a few dollars ends up costing more in the long term. Disposal of unused chemicals always will cost more than any cost savings from larger sized packages.
3. **Date label your chemicals, and only buy from chemical supply companies that date label their chemicals.**
   Chemicals age at different rates, and knowing the age of your chemicals may help you determine if they are still usable.
4. **Use older chemicals first before they decompose.**
   This requires date labeling of chemicals.
5. **Provide good climate control for the chemical storeroom.**
   Store chemicals in a cool, dry environment. Heat and humidity quickly degrade chemicals, resulting in materials that are unsuitable for laboratory use and require disposal. This is particularly important during the summer months when many schools may turn off their air conditioning.
6. **Ventilate your storeroom.**
   Providing a continuous air exchange in your storeroom is not only safer for you, but it will provide a better environment for storage of chemicals.
7. **Label all chemicals and laboratory solutions.**
   Any unlabeled bottle becomes a chemical disposal nightmare; first the chemical must be identified, then it must be discarded properly. To avoid unknown and unwanted solutions, replace or repair old labels and immediately label all prepared solutions.
8. **Prepare only enough solution for immediate use.**
   Preparing extra solution for storage frequently results in many bottles of unwanted solutions that ultimately require disposal.

Be proactive... Reduce chemical waste starting today.

9. **Never store chemicals or solutions in "homemade" bottles.**
   Storing solutions in containers not designed for chemical storage leads to a shorter shelf life of the laboratory chemical. "Homemade" bottles may not provide suitable protection from the environment or may not be compatible with the chemical. Using proper chemical containers will provide safer storage and allow for longer storage of chemical solutions.
10. **Store hygroscopic and deliquescent chemicals in *Chem-Saf*™ bags.**
    Make sure the caps are on tight and use Parafilm M® around the cap for extra protection. *Chem-Saf*™ bags and tight caps help keep moisture out of containers and greatly increases their shelf life.
11. **Follow good laboratory practices.**
    Never allow students to place chemicals back into a chemical reagent bottle. Contamination from student use will dramatically reduce purity and the shelf life of a chemical. To enforce this practice, place smaller amounts of chemicals in beakers or bottles for dispensing.
12. **Microscale your labs.**
    Microscale laboratory procedures can reduce your wastes a hundredfold. Many times the quantities produced in a microscale lab can be disposed of down the drain. If you microscale your labs, also microscale the quantity of chemicals you purchase (see step 2).
13. **Purchase chemical demonstration kits or student laboratory kits that contain the exact quantities of chemicals.**
    This eliminates storage and disposal of "extra" chemicals. Flinn chemical demonstration kits contain enough chemicals to present the demonstration seven times. At the end of the day, there are no unused or unwanted chemicals.
14. **Look at disposal procedures first.**
    When choosing a lab or demonstration, look at the disposal procedure first. If the disposal procedure is difficult, consider using microscale techniques or substituting less hazardous materials. Avoid the use of heavy metals whenever possible.
15. **Neutralize, reduce byproducts and dispose of chemicals immediately after they are generated.**
    Do not stockpile unwanted byproducts or other laboratory wastes from chemical reactions or experiments. Treat chemical byproducts or leftover solutions as part of the experimental procedure. This is safer and easier than stockpiling chemicals for a massive disposal at the end of the year.
16. **Identify hazardous waste, and keep waste solutions separate.**
    Never mix leftover chemicals or byproducts from different labs unless the materials have identical disposal methods and are chemically compatible. Adding a small amount of a lead compound to a waste bottle necessitates licensed hazardous waste disposal of the entire contents due to heavy metal contamination.

Implementing and following these 16 steps to minimize chemical waste will save money and improve the overall safety profile of your school.

Laboratory Chemical **Disposal**

Before You Undertake Any Disposal Procedure—Please Read this Narrative!

Chemical disposal is a routine part of laboratory science programs. Most lab activities will generate some leftover chemicals, solutions and chemical byproducts that will require proper disposal. Advance planning and preparation will help you minimize the amount of hazardous waste generated and reduce the time and resources needed to dispose of excess nonhazardous chemicals or chemical byproducts.

Every school should have a Chemical Hygiene Plan that outlines appropriate policies and procedures for disposing of laboratory chemical byproducts and correctly identifying hazardous waste requiring licensed disposal. The first step in any laboratory waste policy should attack the problem at its source—where and when waste is generated. Careful planning, tailoring lab activities to clear curriculum objectives, adopting microscale lab techniques and substituting safer chemicals will help you reduce the amount of waste generated. (See the article "16 Steps to Minimize Chemical Disposal" on page 733.)

Laboratory chemical disposal requires specific knowledge and procedures. Knowing the type of sewer system your school has and understanding all federal state, and local regulations that may apply are important steps in laboratory chemical disposal. Before you choose a disposal method, it is absolutely essential that you review your plans with regulatory officials. Do not assume that because we publish a set of disposal methods that these methods are "approved" or have the "blessing" of regulatory officials—NOT SO! In publishing laboratory waste disposal methods, we assume that:

- ▶ You will consult with local regulatory officials before proceeding.
- ▶ You will act responsibly with respect to all regulations.
- ▶ The quantity of material involved is very small (i.e., laboratory quantities).
- ▶ Only trained personnel will attempt the methods.

DO NOT USE THESE METHODS if they do not meet local regulations, if the quantity of material is not small or if you are not comfortable with a disposal procedure.

Advance knowledge, preparation and planning also will allow you to dispose of laboratory waste safely and effectively. There are three main categories of laboratory waste generated:

- ▶ Biological or biomedical waste (preserved materials, "live" material remains, culture products)
- ▶ Chemical waste (unused testing solutions, reaction products, stains and indicators)
- ▶ Hazardous waste requiring licensed disposal

Biological Waste

Biological science experiments may produce hazardous waste. Special attention should be paid to all microbiological culture products since they may contain harmful organisms. Preserved materials, deceased living materials and all "sharps" also deserve special attention prior to disposal. To assist with handling biological wastes, Flinn Scientific has developed a biological waste disposal procedure. Please review pages 754–755 for a thorough discussion and detailed procedures for the safe disposal of of biological waste materials.

Chemical Waste From Laboratory Experiments

Before performing any laboratory activity, review the properties of the chemicals required and any products that may be generated. If the reactants or products present unique hazards or will require specialized disposal (e.g., flammable organic solvents), consider modifying the experiment or finding a different experiment that will teach the same concept. Flinn Scientific maintains an extensive library of tested laboratory activities. Please call (1-800-452-1261) or email us (flinn@flinnsci.com) for suggestions of safe laboratory activities.

The catalog entry for every chemical listed in the Chemicals section of this *Flinn Scientific Catalog/Reference Manual* includes a Flinn Suggested Disposal Method number in the product description. Simply look up the product in the alphabetical section of the chemical listings and determine the disposal number. Then refer to this Suggested Disposal Methods on pages 736–753.

For best results, incorporate treatment of leftover chemicals and reaction byproducts into any laboratory activity involving chemicals. Collect all solutions or similar products in a centrally located container. For example, if students are working with acidic solutions with a pH <2, have them pour their products into one beaker placed in the hood or other central location. The acid solution may then be neutralized with base according to Flinn Suggested Disposal Method #24b at the end of the lab period. Making disposal a routine part of every lab activity teaches students that concern for the environment is everyone's responsibility and that scientists working in the lab also take this responsibility seriously.

Inventory Management and Laboratory Chemical Disposal

Chemicals, supplies and equipment tend to accumulate in the science department over time and can lead to hazardous situations. Effectively managing the chemical inventory in the school will help you reduce the amount of chemical waste and the potential impact of waste disposal on your school's budget and resources. The chemical storeroom should be cleaned out on a regular basis. Before you undertake chemical cleanout and disposal, enlist the active consent and participation of school or district administrators and facilities or risk managers to provide adequate resources. Hasty responses to chemical disposal are often expensive, unsafe or harmful to the environment.

Inspecting and Preparing the Inventory

Carry out a preliminary inspection to determine if cleanout and disposal are warranted. Look for the following:

- Bottles and containers that are broken, corroded or have crystals growing around the caps or liquid seeping out of closures.
- Inappropriate storage containers, such as beakers, flasks, buckets, plastic soda bottles or food jars.
- Poorly labeled containers used for storing solutions or transferring chemicals. Labels must have the chemical name, concentration, date and appropriate hazard information and warnings.

Prepare or update the annual chemical inventory and identify chemicals you want to keep. Laboratory chemicals and preserved materials that are no longer part of the curriculum should be removed as should chemicals that are dangerously toxic, potentially explosive, contaminated or decomposed, mislabeled, out-of-date or present in surplus amounts. Assemble a list of chemicals requiring disposal. Include the full name of the chemical, the quantity printed on the bottle's label and the number of bottles of each size. The size of the bottle is often more important than the quantity of material if the whole bottle must be removed and shipped to a disposal facility. The cost may be equal whether there are 1 or 100 bottles in a drum.

Chemical Disposal

Research the properties of unneeded chemicals to determine any that may be neutralized, reduced, precipitated and/or disposed of in the trash or down the drain. The description for each chemical in your current *Flinn Scientific Catalog/Reference Manual* includes a disposal number. This number refers to one of the generally allowed, suggested disposal methods listed in the reference section of the catalog. Please verify state and local regulations that may apply as some methods may not be permitted in particular areas. Disposal options also may be limited by the type of septic system the school has.

Review the following general guidelines and safety rules before attempting any disposal procedure.

LABORATORY CHEMICAL DISPOSAL continued on next page.

Laboratory Chemical Disposal, continued

- The quantity of material should be small—laboratory quantities only.
- Make sure you have read and understand the chemistry involved in the procedure.
- Never work alone!
- Always wear appropriate personal protective equipment.
- Perform all procedures in a laboratory environment with good ventilation.

Hazardous Waste Disposal

Some chemicals, such as heavy metal salts (e.g., Cr, Pb, Ba) and halogenated solvents, always will require licensed hazardous waste disposal assistance. The EPA has published a very thorough workbook to help you evaluate options with respect to chemical cleanout and hazardous waste disposal. "Building Successful Programs to Address Chemical Risks in Schools" available online at www.epa.gov/schools/workbk.pdf, encourages academic institutions to identify district and community stakeholders that are vested in safe chemical management. Local fire and police departments, area colleges and universities, industry partners and trade and professional organizations may be able to provide advice and assist with packaging chemicals for removal, removing mismanaged or unnecessary chemicals and properly disposing of chemicals. The following options will help you identify potential partners and resources to investigate, plan and carry out chemical disposal.

- Contact the facilities staff for information about ongoing chemical disposal programs.
- If applicable, get in touch with your state science supervisor or department of education. Many states have implemented chemical clean-up campaigns in recent years. The state EPA may also have an existing program.
- Work with the state and local associations. Use the experience of other teachers who have faced similar issues to help your school comply with chemical disposal requirements.
- Seek the advice of your Environmental Health and Safety Department or that of a nearby college or university. Most large universities have ongoing waste disposal programs and understand state and local requirements.
- Contract with a licensed hazardous waste disposal firm for removing chemicals. Because the institution has cradle-to-grave responsibility for its chemicals, even after they have been removed from the site, it is vital that you choose a licensed and reputable firm. Ask for and check references, and do not automatically choose the lowest bid. Request a certificate of disposal for the chemicals.

Flinn Suggested Laboratory Chemical Disposal Methods

Flinn Scientific has been publishing suggested laboratory chemical disposal methods for more than 40 years. Each chemical in the *Flinn Scientific Catalog/Reference Manual* has a disposal number under its name. The disposal number refers to one of the suggested disposal procedures listed in this section. As federal, state, and local regulations have changed, many disposal procedures have been updated or deleted. Before attempting any disposal procedure, it is essential that you check local regulations to determine if it is allowed in your locale.

Before attempting any disposal procedure, the following safety rules must be followed:

- ▶ Never work alone!
- ▶ Always were appropriate personal safety equipment.
- ▶ Perform all procedures in a laboratory environment with proper ventilation. Note that a fume hood is required for some procedures.

If you have any questions concerning laboratory chemical disposal methods, please call (1-800-452-1261) or email (flinn@flinnsci.com) the Technical Services department at Flinn Scientific, Inc.

IF YOU LIKE OUR
CATALOG
REFERENCE
MANUAL
SEND US YOUR ORDER

Did You Know It Is Always Yours?

Hazardous waste chemicals are yours *FOREVER!* As the generator, your institution will be held responsible in perpetuity for hazardous waste. Even if you contract with a firm to remove the material from your school, it remains yours forever. With that in mind, always know and get references for the firm you hire to remove such materials. As one instructor belatedly said after a sad series of disposal events, "I should have known I was in trouble when they came in a rented truck."

Flinn Suggested **Disposal Methods**

FLINN METHOD

#1a Organic Acid Halides and Acid Anhydrides

Products in this class readily react with water, amines and alcohols. They are also generally corrosive and their vapors are lachrymators. Acid halides and acid anhydrides may be RCRA listed and/or characteristic wastes due to their reactivity or flammability. Leftover organic acid derivatives remaining in an experiment may be hydrolyzed to water-soluble products of low toxicity that can be flushed down the drain. The reactions are exothermic; immerse the reaction vessel in ice water to control the heat.

Examples

Adipoyl chloride and acetic anhydride

Saturated solution of sodium carbonate (200 g Na_2CO_3/L)

Materials Required

Hydrochloric acid, HCl, 3 M
Ice–water bath (optional)

Large glass or polyethylene container
pH paper
Stirring rod

Overview

Acid halides and acid anhydrides are reacitve derivatives of carboxylic acids. These substances react with water to form the original organic acid or its conjugate base in basic solution. Excess acid halide or acid anhydride remaining in a reaciton mixture may be decomposed with saturated sodium carbonate solution. The acid anhydride or acid halide reacts with water, and the products of that reaction, which are acidic, immediately react with sodium carbonate to form a salt of the acid. Most carboxylic acid salts are innocuous and may be flushed down the drain. Gaseous carbon dioxide is also produced, also forms, which will produce a fizzing as the reaction proceeds. The reaction of acetic anhydride proceeds as follows:

$$(CH_3CO)_2O + H_2O \rightarrow 2CH_3COOH$$
$$2CH_3COOH + Na_2CO_3 \rightarrow 2NaCH_3COO + CO_2 + H_2O$$

Note that one mole of sodium carbonate is required to fully neutralize one mole of the original acid halide or acid anhydride. To push the reaction to completion, a twofold molar excess of sodium carbonate is recommended. At 25 °C, a saturated sodium carbonate solution contains about 2 moles of sodium carbonate per liter of solution. Sodium hydroxide solution (2 M) may be substituted for saturated sodium carbonate in this procedure.

Both adipoyl chloride and sebacoyl chloride contain two chlorine atoms per molecule. Use a fourfold molar excess of sodium carbonate solution to hydrolyze these compounds.

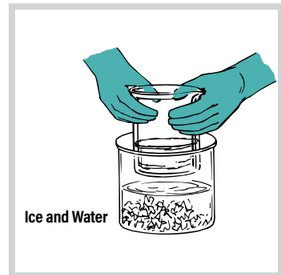
Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemicals-resistant gloves and a lab coat or chemical-resistant apron.

2. Place a saturated solution of sodium carbonate in a large glass or plastic container.

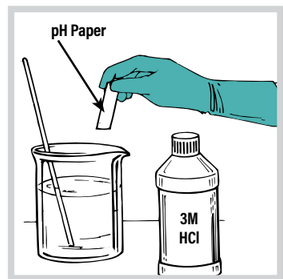
3. Slowly add a few milliliters or grams of the acid halide or anhydride to the container while constantly stirring. You can tell the decomposition reaction is occurring when the material begins to dissolve. The evolution of gaseous carbon dioxide should also be evident.

4. If a noticeable temperature rise is observed, place the container in an ice–water bath.



5. Continue slow addition of the acid derivative while stirring until all the compound has been consumed.

6. When a clear solution has been obtained, cool it to room temperature and neutralize to pH 7 with 3 M hydrochloric acid.



7. Flush the neutral mixture down the drain with a 20-fold excess of water.

QUESTIONS? CALL US AT
1-800-452-1261

Please... Read the Narratives

Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures may not be used in some jurisdictions. All procedures involve some hazards and risks. Once again... read the narratives that precede these specific chemical disposal methods.

FLINN METHOD

#1b Water-Reactive Metal Halides

Products in this class may react vigorously with water. The reactions generate heat and the reaction products are strongly acidic. Water-reactive metal halides may be decomposed to products suitable for flushing down the drain by reacting them with a large excess of cold water and neutralizing the resulting acidic solution.

Examples

Aluminum chloride (anhydrous) and tin(IV) chloride

Materials Required

Sodium hydroxide solution, NaOH, 3 M or saturated sodium carbonate solution, Na_2CO_3
Ice water
Large glass or polyethylene container
pH paper

Stirring rod

Overview

As described, these substances react with water, and the products are acidic. For example:

$$SnCl_4 + 2H_2O \rightarrow 4HCl + SnO_2$$

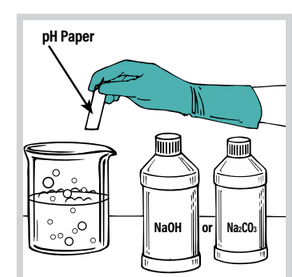
The HCl formed will dissolve in the excess water. It is neutralized with either sodium hydroxide (to form sodium chloride and water) or with sodium carbonate (to form sodium chloride, gaseous carbon dioxide and water).

Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemicals-resistant gloves and a lab coat or chemical-resistant apron.

2. Prepare an ice/water slush in a large glass or polyethylene container. Slowly add the water-reactive metal halide directly to the ice/water slush with constant stirring. Aluminum chloride reacts vigorously with water. Be cautious to avoid localized overheating.

3. When all the compound has been added to the water, allow the mixture to come to room temperature and neutralize to pH 7 with sodium hydroxide or sodium carbonate solution. If you use sodium carbonate solution, expect some evolution of carbon dioxide gas during neutralization. A thick white precipitate of aluminum or tin(IV) oxide will form. Let the mixture settle overnight.



4. Check local sewer discharge limits for any metal cation remaining in solution. Decant the liquid to the drain with a 20-fold excess of water if allowed. The solid residue may be suitable for landfill disposal if no RCRA toxic metals are present.

FLINN METHOD

#2 Aldehydes

Products in this class may be solids, liquids, gases or aqueous solutions. Low-molecular aldhydes may be water-soluble, but they are also fammable and likely Resource Conservation and Recovery Act (RCRA) characteristic wastes. Excess of leftover aldehyde in an experiment my be oxidized to render it nonhazardous.

Examples

Acetaldehyde and benzaldehyde

Materials Required

Potassium permanganate solution, $KMnO_4$, 0.3 M
Sodium sulfite solution, Na_2SO_3, 0.1 M
Sulfuric acid solution, H_2SO_4, 3 M
Beaker, 1-L
Magnetic stirrer/hot plate and stir bar
pH paper
Thermometer

Overview

The carbonyl group in an aldehyde is easily oxidized to a carboxylic acid, which is usually less toxic, less volatile and more water-soluble than the starting aldehyde.

Oxidation can be achieved using aqueous potassium permanganate, and the reaction can be followed by monitoring the color change. As the oxidation occurs, the purple permanganation (MnO_4^-) is reduced to brown, insoluble manganate dioxide. The oxidation of benzaldehyde, for example, leads to benzoic acid and its salt:

$$3C_6H_5CHO + 2KMnO_4 \rightarrow 2C_6H_5CO_2K + C_6H_5CO_2H + 2MnO_2 + H_2O$$

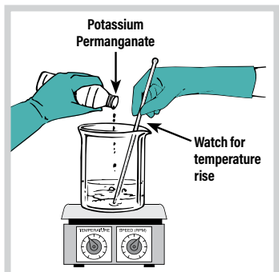
The reaction may need to be heated, and any excess permanganate should be reduced by sodium sulfite before disposal. The mole ratio is two moles of permanganate ion per mole of carbonyl group.

Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemicals-resistant gloves and a lab coat or chemical-resistant apron.

2. Dilute any leftover aldehyde with 100 mL.

3. Add about 30 mL of 0.3 M potassium permanganate solution over a period of 10 minutes. If this addition is not accompanied by a rise in temperature and loss of purple permanganate color, then heat the mixture using a hot plate until the color changes.



FLINN METHOD #2 continued on next page.

Flinn Method #2, continued

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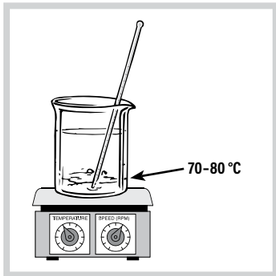
Slowly add additional potassium permanganate solution at 70–80 °C until the purple color does not dissipate. Stir for one hour.



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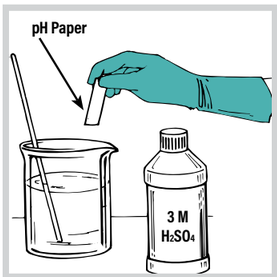
Allow the mixture to cool to room temperature and acidify to pH 7 with 3 M sulfuric acid. If any purple color remains, add 0.1 M sodium sulfite until the mixture is brown.



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Filter the mixture, if needed, to remove insoluble MnO_2, which may be placed in the trash. The remaining solution may be flushed down the drain with a 20-fold excess of water.

FLINN METHOD

#3 Alkali Metals and Alkaline Earth Metals

Materials in this class react with air and water as well as with alcohols and halogenated hydrocarbons. These metals should not be allowed to come into contact with wastes containing these liquids. Alkali metals are stored in a dry mineral oil to keep them from air. The alkaline earth metals are usually covered with a thin coat of metal oxide, which protects them from further oxidation. The alkali and alkaline earth metals are characteristic RCRA hazardous wastes due to their reactivity. Small pieces or shavings of alkali or alkaline earth metals remaining in an experiment may be rendered nonhazardous by **careful** reaction with an alcohol or water, respectively.

Examples

Alkali metals include lithium, sodium and potassium. Alkaline earth metals include magnesium and calcium.

Materials Required

tert-Butyl alcohol (for potassium)
Ethyl alcohol, anhydrous (for sodium and lithium)
Hydrochloric acid, HCl, 1 M
Sodium hydroxide solution, 3 M
Class D fire extinguisher or a large bucket of clean, dry sand
Knife to cut large pieces of metal (optional)
Large glass beaker
Magnetic stirrer and stir bar or stir rod
pH paper

Overview

Alkali metals are very reactive with water to produce a base (e.g., NaOH), hydrogen gas and heat. They also react with alcohols in a more controlled manner to give similar products. The reaction is slower in alcohol due to the lower acid dissociation constant of alcohol relative to water.

$$Na + CH_3CH_2OH \rightarrow CH_3CH_2O\,Na + \tfrac{1}{2}H_2$$

This procedure produces hydrogen gas, which is an explosion and fire hazard. The procedure also requires ethyl alcohol, another explosion and fire risk. Perform this procedure in a fume hood, behind a shield and with proper safeguards.

Anhydrous alcohols contain very little water and are preferred in this procedure. Use anhydrous ethyl alcohol for sodium or lithium and tert-butyl alcohol for potassium.

Leftover potassium is extremely dangerous due to its reactivity and tendency to form explosive peroxides. Appearance of a crumbly yellow coating indicates the formation of potassium superoxide (KO_2). Cutting or handling old potassium may result in a violent explosion. Do not attempt to destroy yellow-coated potassium. Contact a licensed hazardous waste disposal company.

Care must be taken in decomposing leftover alkali metals with alcohol. All the metals must be reacted with alcohol before water is added. Many laboratory accidents and fires have occurred by rushing this procedure and adding water too soon. The water will react with a small piece of metal generating substantial heat that autoignites the flammable alcohol.

Calcium and magnesium are less reactive with water. Leftover calcium is easily disposed of using a large amount of cold water, while excess magnesium requires dilute acid to catalyze the reaction.

$$Mg + 2H_2O + H^+ \rightarrow Mg(OH)_2 + H_2$$

Procedure A: For Sodium and Lithium Metal

1a

Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2a

Place small pieces of leftover or excess sodium or lithium in a 500-mL beaker and cover with mineral oil.

3a

Slowly add ethyl alcohol (at least 13 mL per g of sodium, 30 mL per g of lithium) to the metal at a rate to cause a reasonable hydrogen evolution. Do not add the ethyl alcohol too fast (causing excessive heat generation). Stir the mixture until all the pieces of metal have dissolved.

FLINN METHOD #3 continued on next page.

Please… Read the Narratives

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Flinn Method #3, continued

4a

Only after all pieces of metal are gone, slowly add an equal volume of water to the mixture. Neutralize with 1 M hydrochloric acid.

5a

Flush the neutralized mixture down the drain with a 20-fold excess of water.

Procedure B: Potassium Metal

1b

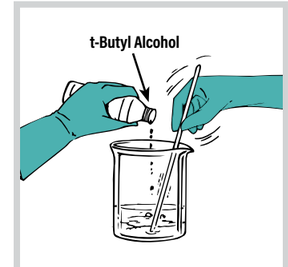
Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2b

Place small pieces of leftover potassium metal in a 500-mL beaker and cover with mineral oil.

3b

Slowly add tert-butyl alcohol (at least 21 mL per g of potassium) to the metal at a rate to cause a reasonable hydrogen evolution. Stir the reaction mixture until all the pieces of metal have dissolved.



4b

Only after all pieces of potassium are gone, slowly add an equal volume of water to the reaction mixture. Neutralize with 1 M hydrochloric acid.

5b

Flush the neutralized mixture down the drain with a 20-fold excess of water.

Procedure C: Calcium and Magnesium Metal

1c

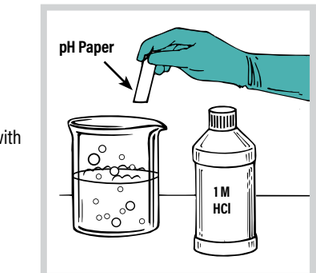
Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2c

Add small increments of leftover metal (1–2 g) to 1 L of cold water (for calcium) or dilute (1 M) hydrochloric acid (for magnesium). Stir the mixture until all the metal has dissolved.

3c

Using pH paper, neutralize to pH 7 with 1 M hydrochloric acid.



4c

Flush the solution down the drain with a 20-fold excess of water.

FLINN METHOD

#4a Picric Acid

Picric acid is explosive when dry. Do not touch or handle. Picric acid cannot be disposed of by untrained personnel. You must contact a commercial waste disposal service, the local bomb squad or fire department. Bouin's solution contains picric acid; treat it just as carefully as pure picric acid.

Examples

Picric acid, Bouin's solution

Overview

Picric acid is normally sold containing 10–15% water, and in this state it is relatively safe to handle. However, dry picric acid is very explosive. The explosion can be initiated by friction, shock or sudden heating. Picric acid also reacts with metals to form explosive metal picrates, which are highly sensitive to detonation. **Do not attempt to dispose of picric acid by chemical means. This procedure merely provides a means to wet the picric acid to decrease its hazards.**

Procedure

1

Wear a full face shield, chemical-resistant gloves and a lab coat or chemical-resistant apron.

FLINN METHOD #4a continued on next page.

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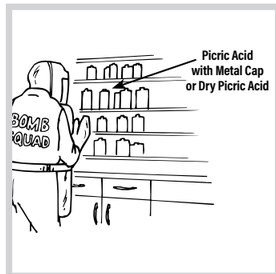
Flinn Method #4a, continued

2

Without touching the container of picric acid, determine if it has a metal cap. If it does, *do not touch the container at all.*

3

A metal-capped container of picric acid should be handled only by a trained expert, such as a member of a bomb squad. Call such an expert to remove the material from the premises as soon as possible. (Picric acid can form salts with the metal in the cap, and these salts are more explosive than picric acid itself. The friction caused in attempting to remove the metal cap from a container of picric acid has been reported to cause detonation of minute amounts of metal picrate trapped in the threads of the cap.)

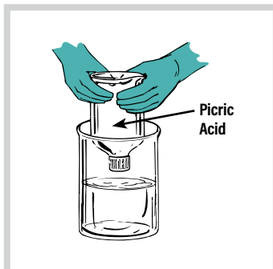


4

If—and only if—the container of picric acid has a plastic cap **and** contains visible water, you may proceed.

5

Move the bottle to a fume hood and immerse the plastic-capped container upside-down in a beaker of water. Contact a licensed hazardous waste disposal company for further instructions and to remove the material.



FLINN METHOD

#4b Halogenated Hydrocarbons

Halogenated hydrocarbons require licensed hazardous waste disposal due to their characteristic toxicity or flammability. Halogenated organic waste should be segregated from other flammable organic solvents. The best route for disposal of nonvolatile halogenated hydrocarbons is through incineration. Use a licensed hazardous waste disposal company as described in Flinn Disposal Method #26c or #27j.

FLINN METHOD

#4c Organic Acids, Substituted

Substituted organic acids include amino acids and halogenated carboxylic acid (e.g., chloroacetic acid). Amino acids are nonhazardous, water-soluble and suitable for landfill or drain disposal using Flinn Disposal Method #26a or #26b. Water-soluble substituted carboxylic acids and their sodium, potassium, calcium or magnesium salts can be rinsed down the drain if local sewer discharge limits permit. See Flinn Disposal Method #26b.

FLINN METHOD

#5 Amines, Aromatic

Aromatic amines are relatively toxic and flammable materials. Common aromatic amines, such as, pyridine, aniline and diphenylamine, require licensed hazardous waste disposal according to Flinn Disposal Method #26c.

Many common dyes and pigments contain aromatic amine groups and do not present any unusual problems for incineration or burial in a landfill. Please consult your local regulations and Flinn Disposal Method #26a.

FLINN METHOD

#6 Substances Precipitated by Calcium Ion

Substances in this class include (a) soluble metal salts containing the fluoride ion and (b) soluble salts containing the oxyanion of a toxic heavy metal (e.g., Mo, W) for which the calcium salt is quite insoluble. Fluoride ion is highly poisonous.

Do not use procedure for hydrofluoric acid. Hydrofluoric acid is a poison and extremely dangerous in contact with human flesh. It requires licensed hazardous waste disposal.

Examples

Sodium fluoride, sodium molybdate, sodium tungstate

Materials Required

Calcium chloride solution, $CaCl_2$, 1 M, in threefold molar excess for disposal of fluoride or other salts
Hydrochloric acid, HCl, 3 M, or sodium hydroxide, NaOH, 3 M, as necessary to adjust pH
Funnel, filter paper and flask
Large plastic beaker or similar container (don't use glass for HF)
pH paper
Wood stirring stick

Procedure

1

Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2

Dissolve the soluble compound (metal salt) in the smallest amount of water possible.

3

Adjust the pH to 7 using pH indicator paper by adding 3 M sodium hydroxide or hydrochloric acid as necessary.

4

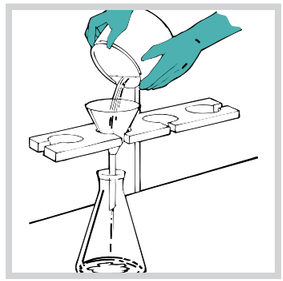
While stirring, add 1 M calcium chloride solution in a threefold molar excess to the neutral solution. Allow the resulting precipitate to stand about 15 minutes.

FLINN METHOD #6 continued on next page.

Flinn Method #6, continued

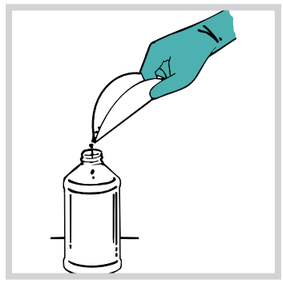
5

Filter or decant off the supernatant liquid. Flush the liquid down the drain with excess water.



6

Allow the solid to dry, place it in a plastic container, and send it to a landfill.



FLINN METHOD

#8 Azides and Azo- Compounds

Metal azides require licensed hazardous waste disposal as described in Flinn Disposal Method #26c. **Azides should NOT be drain-disposed.** They react with lead and copper in drain lines, solder joints and brass fittings to form unstable and explosive products. Drain systems have been destroyed by such explosions. In addition, azides are not biodegradable and will kill the necessary bacteria present in the digestion system of wastewater treatment plants. Stocks of these materials should be kept low. Sodium azide is a P-Listed acutely hazardous waste.

FLINN METHOD

#9 Carbon Disulfide

Carbon disulfide is a P-Listed acutely toxic hazardous waste (P022). Any discarded commercial chemical product containing carbon disulfide as the sole active ingredient will require licensed hazardous waste disposal. Proper management of P-Listed wastes is extremely important because institutions that accumulate more than 1 kg on site at anytime of acutely hazardous waste will be subject to the most stringent requirements for listing, storing and reporting all their hazardous waste.

Please... Read the Narratives

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FLINN METHOD

#10 Bases, Strong and Weak and Basic Anhydrides

Elementary neutralization of corrosive acid and base solutions is a generally allowed disposal procedure. Two simple rules should be followed. First, the neutralization process should be mild. Any strong acids or bases should first be diluted to a concentration around 1 M or 10%. Second, the final product must be near neutral (pH 5–9) before discharge to the drain. In this procedure, bases are neutralized with dilute hydrochloric acid.

Examples

Ammonium hydroxide, sodium hydroxide

Materials Required

Hydrochloric acid, HCl, 3 M
Glass stirring rod
Ice/water slush (optional)
Large glass beaker
pH paper

Overview

Bases react with acids in aqueous solution to form a salt and water.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

The neutral soluble salts formed are generally innocuous and can be rinsed down the drain with water.

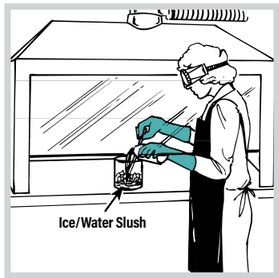
Procedure

1

Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron. Use a fume hood if neutralizing ammonia solutions.

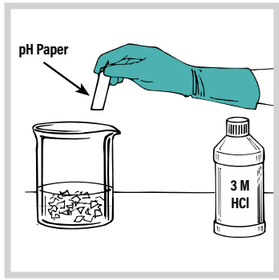
2

Prepare a dilute solution of (1 M or <10%) base by diluting a more concentrated solution or dissolving the solid into water. Considerable heat may be generated when dissolving a solid base. Use an ice/water slush if needed to dissolve solid sodium or potassium hydroxide.



3

When solution is complete, slowly add 3 M hydrochloric acid until the mixture is neutralized. Check with pH paper. More heat may be evolved in the neutralization process.



4

Rinse the neutral mixture down the drain with a 20-fold excess of water.

FLINN METHOD

#11 Silver Compounds

Silver and silver compounds are expensive and may be recovered or recycled but often can be reclaimed for future use. Silver compounds are characteristic hazardous wastes. Silver compounds are identified by the EPA as characteristic hazardous wastes due to their toxicity. According to the Resource Conservation and Recovery Act (RCRA), the concentration of silver ions in an extract of a solid suitable for landfill disposal cannot exceed 5 mg/L, based on the Toxicity Characteristic Leaching Procedure (TCLP). Federal guidelines also impose a concentration limit of 5 mg/L on industrial sewer disposal of silver ions in solution. Check with your local sewer authority for the allowable discharge limit in your area. In most cases, dilution with water is not an acceptable means of achieving the concentration limit.

Examples

Silver nitrate, silver chloride, silver oxide

Materials Required

Nitric acid, HNO_3, 8 M
Sodium chloride, NaCl, 1 M
Sodium hydroxide, NaOH, 2 M
Sodium hydroxide, NaOH, 6 M
Sucrose
Filtration apparatus
Glass stirring rod
Large glass beaker
Magnetic stirrer/hot plate with stir bar

Silver Recovery

Silver may be recovered and recycled for future use by dissolving the metal or metal compound in nitric acid, precipitating silver chloride and reducing the latter to silver metal. Recovery of silver metal from AgCl may be achieved by reduction with sucrose in basic solution or zinc metal in acid solution. The first step must be done in a fume hood due to the possible production of NO_2, a toxic brown gas. Note that $PbCl_2$ will co-precipitate with AgCl in the second step if the original silver is contaminated with lead. The third step may be omitted, and the silver reclaimed in the form of the precipitated silver chloride, if the original silver was relatively pure (see Procedure A).

The chemical reactions are as follows. Oxidation of silver metal may occur by one of two possible mechanisms:

$$2Ag(s) + 2HNO_3 \rightarrow 2AgNO_3(aq) + H_2(g)$$

or

$$Ag(s) + 2HNO_3(aq) \rightarrow AgNO_3(aq) + NO_2(g) + H_2O$$

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

$$AgCl + NaOH(aq) + Sucrose \rightarrow Ag(s)^*$$

*Sucrose is hydrolyzed to the reducing sugars glucose and fructose in basic solution. These sugars are oxidized to gluconic acids in the process of reducing Ag^+ ions to silver metal. The silver metal will be obtained in the form of a brown powder.

Silver(I) compounds, such as AgCl, are photosensitive and must be stored in dark bottles to prevent light-catalyzed reduction to silver.

Silver or silver ions may also be precipitated in the form of silver chloride to reduce the volume of hazardous waste requiring disposal (see Procedure B).

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

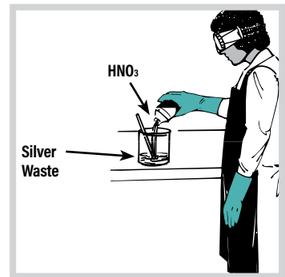
Procedure A: Silver Recovery Process

1a

Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2a

Dissolve the silver metal or silver salts in 8 M nitric acid solution. For about 10 g of silver, use 20–30 mL of 8 M nitric acid.

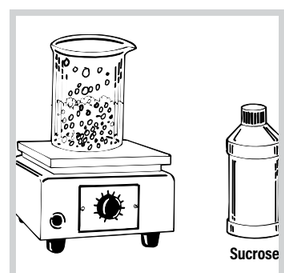


3a

Add sodium chloride (about 60 g per 100 g of Ag) to precipitate silver chloride. Filter and wash the precipitate. (This step is necessary to rid the silver of any copper contaminant.)

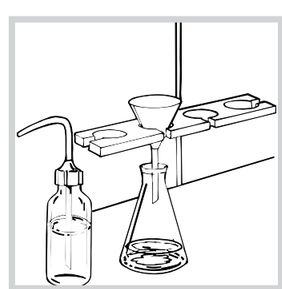
4a

Suspend the AgCl in 6 M NaOH (for 100 g of Ag, use about 500 mL of NaOH) and boil it for about 30 minutes, during which time add sucrose (about 250 g or 1 cup per 100 g of Ag) in small amounts at frequent intervals. Stirring is not necessary, only occasional swirling. At first there is considerable frothing, and then the solution becomes dark brown. Finally a heavy, gray precipitate forms.



5a

Filter, wash and dry this precipitate. Store in a dark bottle.



FLINN METHOD #11 continued on next page.

Flinn Method #11, continued

Procedure B: Disposal of Silver Salts

1b

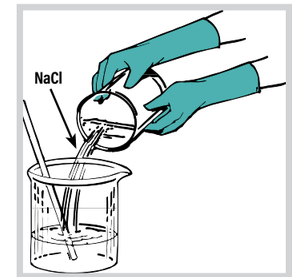
Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2b

Dissolve the silver salt in water in a beaker.

3b

Add a 50% molar excess of sodium chloride solution and stir to ensure complete mixing.



4b

Decant or filter the resulting precipitate of silver chloride.

5b

Allow the precipitate to dry and dispose of it via licensed hazardous waste disposal.

6b

Check the supernatant liquid for residual silver, and rinse it down the drain with a 20-fold excess of water.

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FLINN METHOD

#12a Oxidizing Agents

Strong oxidizing agents, such as chlorates, permanganates and chromates, are hazardous when in contact with combustible materials. They should *never* be discarded with general refuse as they may cause fires or form explosive mixtures. Oxidizers are classified as characteristic hazardous wastes by the EPA due to their ignitability, (i.e., their ability to add oxygen to and sustain or intensify a fire involving a combustible material). Examples include nitrates, inorganic peroxides and permanganates.

Solid oxidizers will require licensed hazardous waste disposal. Leftover solutions of oxidizers remaining at the end of an experiment may be reduced as part of the experimental procedure to render them nonhazardous and suitable for drain disposal. Sodium thiosulfate is the recommended and most commonly used reducing agent for this purpose. Note that in the case of chromates, however, the reduced product will still require licensed hazardous waste disposal due to the chromium content. See Flinn Disposal Method #27f.

Examples

Bromine, iodine, sodium chlorate, potassium permanganate, sodium chromate

Materials Required

Sodium hydroxide solution, NaOH, 1 M
Sodium thiosulfate solution, $Na_2S_2O_3$, 4%
Sulfuric acid, H_2SO_4, 1 M
Glass stirring rod
Large glass beaker
pH paper

Overview

Oxidizing agents by definition oxidize other substances (i.e., they readily react with substances in low oxidation states to raise them to higher oxidation states). The oxidizing agent itself is reduced in this process.

The complementary processes of oxidation and reduction are often accompanied by the evolution of considerable heat. Leftover solutions of oxidizing agents may be reduced as part of an experimental procedure to render them nonhazardous.

Leftover oxidizing agents in solution may be safely reduced with sodium thiosulfate. The reactions proceed best in mildly basic, neutral, weakly acidic solutions. (Too much acid will react with the sodium thiosulfate directly, precipitating elemental sulfur from the mixture.) In the following example, thiosulfate ions react with the bromate ions to produce nonhazardous sulfate and bromide ions. Excess acid must be neutralized with base prior to drain disposal, if allowed.

$$3H_2O + 3S_2O_3^{-2} + 4BrO_3^- \rightarrow 6SO_4^{-2} + 4Br^- + 6H^+$$

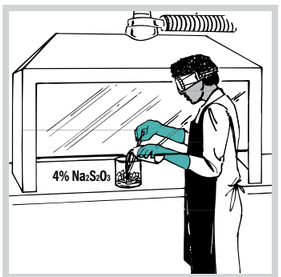
Procedure

1

Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2

This method is for small quantities of laboratory oxidizing agents only. Add the oxidizing agent to a twofold molar excess of a 4% aqueous solution of sodium thiosulfate (hypo) with continuous stirring.



FLINN METHOD #12a continued on next page.

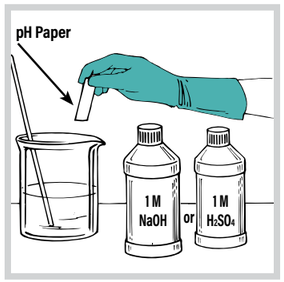
Flinn Method #12a, continued

3

Allow the mixture to stand for about one hour for the redox reaction to proceed to completion. There may be a temperature rise during the reaction.

4

Check the pH of the mixture using pH paper. Neutralize the solution with dilute sodium hydroxide solution or sulfuric acid solution, as needed.



5

The residues from this procedure must undergo further treatment if they contain chromium. The products from the reduction of chromates and dichromates are insoluble chromium hydroxide. These materials can be removed by filtration and require Flinn Disposal Method #27f. Solutions containing chromium ions may not be drain disposed.

6

Flush other solutions down the drain with large quantities of water.

FLINN METHOD

#12b Reducing Agents

Strong reducing agents will react vigorously with oxidizing agents to produce heat and possibly fire. Some reducing agents may cause a fire when in contact with moist combustible materials. A simple oxidation reaction will render most reducing agents safe for disposal.

Examples

Potassium nitrite, sodium sulfite, sodium thiosulfate

Materials Required

Ammonium hydroxide, NH_4OH (proc. B)
Hydrochloric acid, HCl, 1 M
Hydrochloric acid, HCl, 3 M (proc. B)
Sodium carbonate, Na_2CO_3
Sodium hydroxide, NaOH, 1 M
Sodium hypochlorite solution (bleach)
Glass stirring rod
Large glass beaker
pH paper

Overview

Reducing agents by definition reduce other substances (i.e., they readily change the oxidation state of a substance from a high value to a lower value). They are the opposite of oxidizing agents. In the example involving carbon reacting with oxygen, the oxygen was the oxidizing agent because it oxidized the carbon. On the other hand, in this same reaction, carbon is the reducing agent because it changed the oxidation state of oxygen from zero to negative 2 (−2). In the process, considerable heat is produced.

Many reducing agents may be safely reacted with an oxidizing agent that will destroy their reducing power prior to disposal. Sulfides are commonly oxidized using bleach or sodium hypochlorite. This works best in a weakly basic solution. **Never mix bleach with acid!** Dissolve the reducing agent in water, then make it basic with sodium carbonate and finally react it with the hypochlorite ion. After the material is oxidized, the pH is adjusted to neutral and the resulting mixture containing innocuous ions may be flushed down the drain. The reaction of sulfite ion with hypochlorite ion produces sulfate and chloride ions as shown. (see Procedure A).

$$SO_3^{-2} + ClO^- \rightarrow SO_4^{-2} + Cl^-$$

Nitrites are a unique class of compounds in that the nitrogen is in an intermediate oxidation state (+3). It can be either oxidized to the +5 state (NO_3^-) or reduced to a lower state (NO or N_2). Nitrites are easily destroyed by adding 50% excess ammonia and acidifying to pH 1. The resulting product is nitrogen gas. (see Procedure B).

$$HNO_2 + NH_4^+ \rightarrow N_2 + 2H_2O + H^+$$

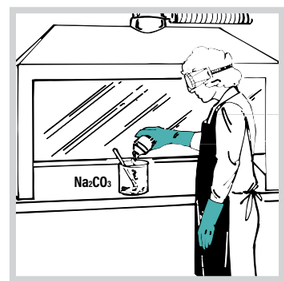
Procedure A: Sulfites

1a

Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

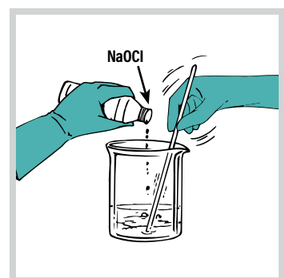
2a

In a large beaker, dissolve an equal amount of sodium carbonate and reducing agent in distilled water.



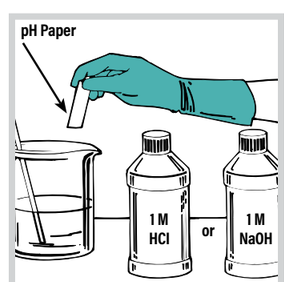
3a

Slowly add a 25% molar excess of bleach to the mixture with continuous stirring. Use caution as the reaction may be vigorous and produce heat. Allow the completed mixture to stand for several hours.



4a

Check the pH of the mixture using pH paper and neutralize as necessary. Use sodium hydroxide solution if acidic or hydrochloric acid solution if basic.



5a

Flush the neutral solution down the drain with a 20-fold excess of water.

FLINN METHOD #12b continued on next page.

Flinn Method #12b, continued

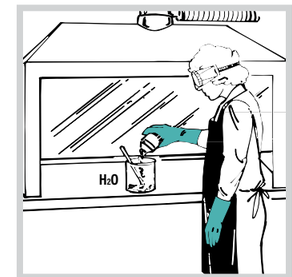
Procedure B: Nitrites

1b

Perform this reaction in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2b

Dissolve the inorganic nitrite salt in distilled water.

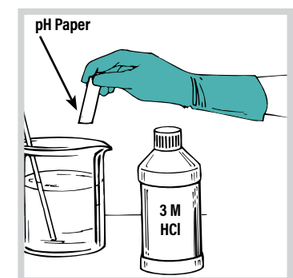


3b

Add a 50% molar excess of ammonium hydroxide solution.

4b

Using pH paper to monitor the process, acidify the solution to pH 1 with 3 M hydrochloric acid. Stir for two hours.



5b

Check the pH of the solution and neutralize to pH 5–10. Rinse the solution down the drain with excess water.

FLINN METHOD

#13 Organic Sulfides, Mercaptans and Thioamides

Organic sulfides and mercaptans are toxic and should not be drain disposed. Because of their toxicity, they should only be disposed of by a licensed hazardous waste disposal company as described in Flinn Disposal Method #26c.

FLINN METHOD

#14 Cyanides and Solid Metal Cyanide Complexes

All cyanides must be removed by licensed hazardous waste disposal. Cyanides are severe and rapid-acting poisons, being quickly absorbed into the body via the respiratory system, skin, eyes and mouth. Cyanides are identified as acutely hazardous, P-listed wastes by the EPA. They are also classified by the Resource Conservation and Recovery Act (RCRA) as characteristic hazardous wastes due to their reactivity with water to produce toxic hydrogen cyanide gas.

Compounds containing metal cyanide complex ions, such as potassium ferrocyanide or potassium ferricyanide, are generally considered nontoxic and are much less reactive than simple cyanide salts. Complex iron cyanides may generate hydrogen cyanide in contact with concentrated hydrochloric acid or when heated. Nevertheless, both potassium ferrocyanide and potassium ferricyanide are classified as P-listed wastes.

The following detoxification procedure using bleach only may be applied to leftover solutions containing ferri- or ferrocyanide ions as part of an experimental procedure. The detoxification procedure may NOT be used to treat any cyanide-containing hazardous waste.

Examples

Potassium ferrocyanide, potassium ferricyanide

Materials Required

Calcium hypochlorite solution, $Ca(OCl)_2$, 30%
Sodium hydroxide solution, NaOH, 3 M (twofold molar excess)
Sodium hypochlorite solution (bleach)
Glass stirring rod
Ice bath (optional)
Large glass beaker
pH paper

Overview

Ferro- and ferricyanides are much less toxic than cyanide salts and are oxidized to cyanates by hypochlorite. A 50% molar excess of bleach is required to assure complete destruction.

$$CN^- + OCl^- \rightarrow OCN^- + Cl^-$$

Commercial bleach (5.25% sodium hypochlorite) or a 30% calcium hypochlorite solution can be used for this procedure.

Procedure

1

Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2

Fill a large beaker ½ full of water and, using pH paper, make it basic (at least pH 12) by adding 3 M sodium hydroxide solution, as needed.

FLINN METHOD #14 continued on next page.

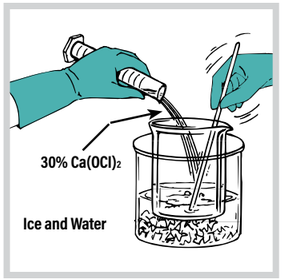
Flinn Method #14, continued

3

Dissolve the iron cyano-complex in the water.

4

While stirring, slowly add the sodium hypochlorite solution (about 100 mL per g of CN) or 30% calcium hypochlorite solution (20 mL per g of CN). Heat may be evolved; maintain the temperature below 50 °C by using an ice and water bath, if necessary. Once the addition of hypochlorite is completed (use a twofold molar excess), allow the mixture to stand for several hours.



5

Rinse the mixture down the drain with a 20-fold excess of water.

FLINN METHOD

#15 Ethers

Bottles of ethers that have been opened and are more than a year old may contain hazardous quantities of explosive peroxides. These bottles will require licensed hazardous waste disposal. Some companies will require that the peroxide level be verified before accepting ethers for disposal.

FLINN METHOD

#16 Hydrazines and Their Salts

Hydrazines contain a nitrogen–nitrogen single bond and are very reactive. Many hydrazines are also toxic and/or carcinogenic. Hydrazines should be disposed of by a licensed hazardous waste disposal company according to Flinn Disposal Method #26c.

FLINN METHOD

#18a Water-Soluble Alcohols, Ketones and Esters

Low-molecular weight, oxygen-containing organic compounds are volatile, soluble in water and biodegradable. Aqueous solutions and extracts containing less than 24% of volatile alcohols, ketones and esters—see the following examples—may be disposed in small quantities down the drain (sanitary sewer only) with excess water. Please check all federal, state and local regulations that may apply before proceeding. See Flinn Suggested Disposal Method #26b for more information on drain disposal.

Examples

Acetone, isopropyl alcohol, ethyl acetate

Please... Read the Narratives

Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures may not be used in some jurisdictions. All procedures involve some hazards and risks. Once again... read the narratives that precede these specific chemical disposal methods.

FLINN METHOD

#18b Hydrocarbons and Flammable Ketones, Esters, Alcohols

Nonvolatile organic compounds do not readily evaporate and are not easily converted into less toxic materials. The only disposal procedures available are disposal by a licensed hazardous waste company.

FLINN METHOD

#20 Organic Amides

Check the Safety Data Sheet (SDS) to determine whether the organic amide will be a characteristic ignitable waste (flash point <60 °C) or if it is a listed waste. Organic amides that are not hazardous wastes may be packaged for landfill disposal according to Flinn Suggested Disposal Method #26a. Characteristic and listed hazardous wastes require licensed hazardous waste disposal (see Flinn Suggested Disposal Method #26c.)

FLINN METHOD

#22a Peroxides, Inorganic

Inorganic peroxides are strong oxidizing agents and are classified by the EPA as ignitable characteristic wastes. Leftover inorganic peroxides may be reduced as part of an experimental procedure. When in contact or mixed with organic or combustible materials, fires or explosions are possible. Do not discard these materials in the trash!

Examples

Hydrogen peroxide, sodium peroxide

Materials Required

Hydrochloric acid, HCl, 3 M
Sodium metabisulfite, $Na_2S_2O_5$, 1 M
Large beaker, ¾ full of water
pH paper
Plastic spoon (optional)
Plastic stirring rod

Overview

Hydrogen peroxide may be reduced with sodium metabisulfite to render it suitable for drain disposal.

Sodium peroxide reacts violently with water to form oxygen gas and sodium hydroxide. Because of this reaction, sodium peroxide is stored in sealed containers to avoid reaction with moisture in the air. With fresh sodium peroxide the reaction with water is quite exothermic, but if used from a previously opened container, it may be less vigorous. Old sodium peroxide may have already slowly converted itself to sodium hydroxide. Test the materials for reactivity by adding a small amount (0.1 g) to water. Evolution of oxygen indicates an active peroxide. Leftover or excess sodium peroxide may be reduced.

$$Na_2O_2 + H_2O \rightarrow 2NaOH + \tfrac{1}{2}O_2$$
$$Na_2O_2 + Na_2S_2O_5 + H_2O \rightarrow 2NaOH + NaHSO_4$$

FLINN METHOD #22a continued on next page.

Flinn Method #22a, continued

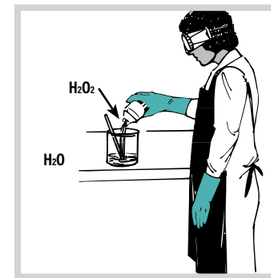
Procedure A: Water Dilution

1a

Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2a

Hydrogen peroxide of any concentration may be disposed of by pouring it into a large beaker containing at least a tenfold excess of water. Stir constantly.

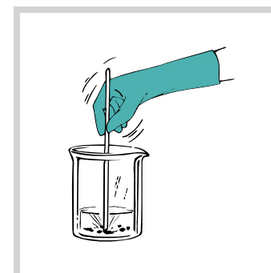


3a

When the mixture is uniform, flush it down the drain with large amounts of extra water.

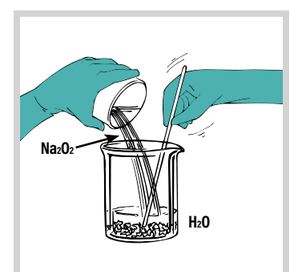
4a

If you are dealing with sodium peroxide, carefully add a small amount of water and break up any lumps with a plastic stirring rod.



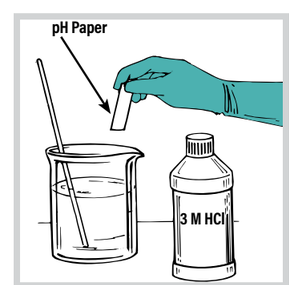
5a

Pour the material slowly with continuous stirring into a large beaker of water. Oxygen gas will evolve, and the solution will become strongly basic. The final amount of sodium peroxide in the water should be no more than 5%. (If you have more sodium peroxide than will fit into this concentration in your beaker, do the procedure again until all the material is disposed of.)



6a

Using pH paper as a monitor, neutralize the solution with 3 M hydrochloric acid.



7a

Flush the neutral solution down the drain with excess water.

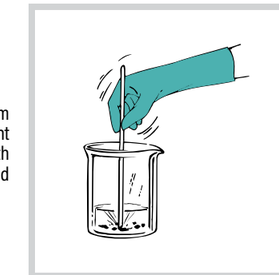
Procedure B: Reduction

1b

Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

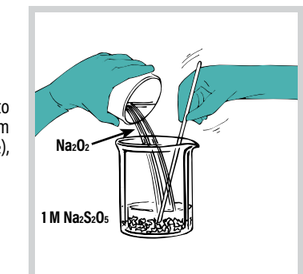
2b

If you are dealing with solid sodium peroxide, carefully add a small amount of water and break up any lumps with a plastic stirring rod. Do **not** grind dry solid.



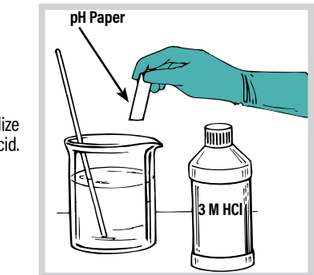
3b

Slowly add the sodium peroxide into a large beaker containing 1 M sodium metabisulfite (100 mL per g of Na_2O_2), and stir continuously.



4b

Using pH paper as a monitor, neutralize the solution with 3 M hydrochloric acid.



5b

Flush the neutral solution down the drain with excess water.

Please... Read the Narratives

Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures may not be used in some jurisdictions. All procedures involve some hazards and risks. Once again... read the narratives that precede these specific chemical disposal methods.

FLINN METHOD

#22b Peroxides, Organic

Organic peroxides are particularly dangerous materials that are highly flammable and explosive. Peroxides are sensitive to heat, shock, friction or contact with combustible materials. These materials are classified by the EPA as characteristic (reactive) hazardous wastes. Leftover organic peroxides may be hydrolyzed as part of an experimental procedure.

Examples
Benzoyl peroxide and lauroyl peroxide

Materials Required
Hydrochloric acid solution, HCl, 6 M
Sodium hydroxide solution, NaOH, 3 M—tenfold volume excess of the material to be destroyed, in a large glass beaker
Glass stirring rod
pH paper
Plastic spoon (optional)

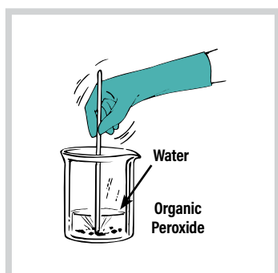
Overview
When reacted with base, benzoyl peroxide and lauroyl peroxide (the only substances we catalog for which this procedure is suggested) will cleave between the two joined oxygen atoms and form sodium benzoate or sodium laurate, which are soluble in water and innocuous. Use care not to go past the neutral point when adding acid to the aqueous solution. If the solution is acidic, some benzoic acid may precipitate out.

$$(C_6H_5CO_2)_2 + 2NaOH \rightarrow 2C_6H_5CO_2^-Na^+ + O_2$$

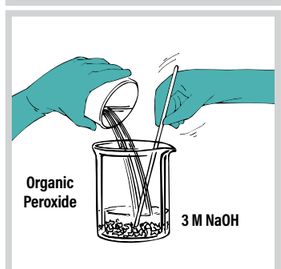
Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron. Exercise caution working with dry organic peroxides—they are friction- and shock-sensitive.

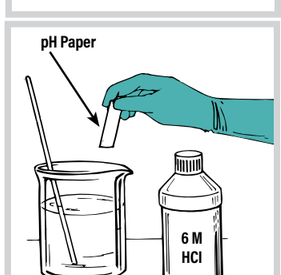
2. Carefully add a small amount of water and break up any lumps in the organic peroxide with a plastic stirring rod. Do **not** grind the dry solid.



3. Pour the material into 3 M sodium hydroxide solution. Allow to stand at least 24 hours, stirring frequently. Benzoyl peroxide has low water solubility, so frequent agitation is important to bring the decomposition reaction to completion.



4. Using pH paper as a monitor, neutralize the solution with 6 M hydrochloric acid.



5. Flush the neutral solution down the drain with excess water.

FLINN METHOD

#23 Sulfides, Inorganic

Inorganic sulfides release highly toxic hydrogen sulfide gas on treatment with acid. These materials are classified by the EPA as characteristic (reactive) hazardous wastes and may not be disposed of in the trash or drain. Leftover soluble inorganic sulfides may be oxidized as part of an experimental procedure.

Examples
Sodium sulfide, ammonium sulfide

Materials Required
Sodium hydroxide solution, NaOH, 0.5 M
Sodium hypochlorite solution, NaOCl
Glass stirring rod
Large glass beaker

Overview
Inorganic sulfides are easily oxidized to sulfate ions using sodium hypochlorite as an oxidizing agent.

$$Na_2S + 4OCl^- \rightarrow Na_2SO_4 + 4Cl^-$$

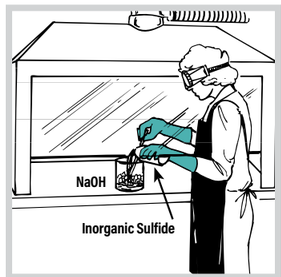
A small amount of base is added to keep the solution basic. A basic solution is needed because inorganic sulfides react with acid to produce highly toxic hydrogen sulfide gas and the hypochlorite ion is more stable at a higher pH.

The products from the reaction are sulfate salts, which are nonvolatile, odorless and have low toxicity. These materials can be rinsed down the drain.

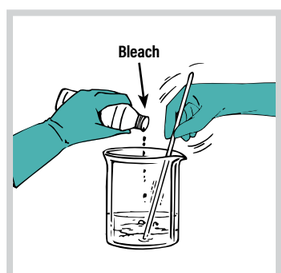
Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2. Dissolve the inorganic sulfide in 0.5 M NaOH solution. For ammonium sulfide, use 100 mL of NaOH solution for every 10 mL of sulfide solution.



3. Slowly add sodium hypochlorite solution (bleach) to the inorganic sulfide. Add 200 mL bleach for each 10 mL of ammonium sulfide or 5 g of sodium sulfide.



FLINN METHOD #23 continued on next page.

Flinn Method #23, continued

4. Allow the solution to sit overnight in the fume hood. Flush the entire solution down the drain with a 20-fold excess of water.

Note: This procedure is **not** intended for use with hydrogen sulfide gas. Gas cylinders must be used completely, vented into a ferric chloride solution through a trap, in an operating fume hood, if needed (due to a leaking valve, for example) and then disposed of in the trash. Small lecture bottles cannot be reused.

FLINN METHOD

#24a Acids, Organic

Organic carboxylic acids can be disposed of by neutralization, solid waste disposal or incineration. Water-soluble organic acids are best disposed of by neutralization with a base to form water soluble sodium salts. Solid, long chain carboxylic acids (e.g., lauric, decanoic) and their salts are insoluble in water, but small quantities pose little risk to the environment. These can be disposed of using Flinn Disposal Method #26a. All other organic acids are best disposed of using a licensed hazardous waste disposal company. Note that all liquids having a pH ≤2 are classified as corrosive wastes and must be neutralized prior to drain disposal.

Use Neutralization Method for These Acids
Acetic acid
Aceto-orcein solution
Barfoed's reagent (Copper carbonate may be formed. Filter and landfill.)
Formic acid
Fumaric acid
Lactic acid
Malonic acid
Oxalic acid
Propionic acid
Succinic acid
Tartaric acid
Trichloroacetic acid

Materials Required
Sodium carbonate, Na_2CO_3, or sodium hydroxide solution, NaOH, 3 M
Glass stirring rod
Large glass beaker
pH paper

Overview
Organic acids that are water soluble readily react with bases to form soluble sodium salts. Some organic acids that have limited solubility in water may produce soluble sodium salts (e.g., benzoic acid) and are also disposed of by this method. Sodium hydroxide solutions or sodium bicarbonate are suitable bases. If sodium bicarbonate is used, carbon dioxide is also formed.

$$CH_3CO_2H + NaHCO_3 \rightarrow CH_3CO_2Na + H_2O + CO_2$$

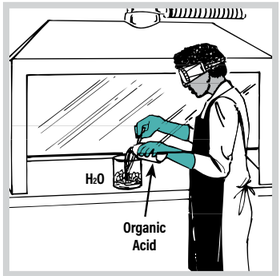
Please... Read the Narratives

Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures may not be used in some jurisdictions. All procedures involve some hazards and risks. Once again... read the narratives that precede these specific chemical disposal methods.

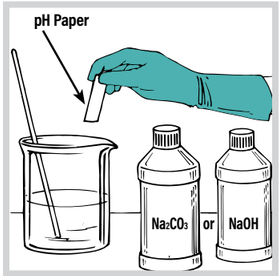
Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2. The organic acid may be diluted by adding it slowly to a 20-fold excess of water while stirring.



3. Neutralize the resulting solution with sodium carbonate or sodium hydroxide solution and check the pH of the final solution with pH paper. Stir the solution until all solid organic acids have dissolved.



4. Adjust the pH of the mixture to 5–9, if needed, and rinse the solution down the drain with an excess of water.

FLINN METHOD

#24b Acids, Inorganic

Neutralization of acid and base solutions (corrosive wastes) is a generally allowed disposal procedure and should present minimal problems. Two simple rules should be followed. First, the process should be mild. Any strong acids or bases should first be diluted to a concentration around 1 M or 10%. Remember, always add acid to water. Second, the final product must be near neutral (pH 5–9) before discharge to the drain. In this procedure, acids are neutralized with sodium carbonate.

Examples
Hydrochloric acid, sulfuric acid, nitric acid

Materials Required
Sodium carbonate solution, Na_2CO_3, 1 M
Glass stirring rod
Large borosilicate glass beaker less than ½ full of water
pH paper

Overview
This procedure is a standard neutralization of an acid with a carbonate. Neutralization may be highly exothermic. Immerse the reaction vessel in an ice bath to control the temperature, if needed.

$$2H_3PO_4 + 3Na_2CO_3 \rightarrow 3CO_2 + 2Na_3PO_4 + 3H_2O$$

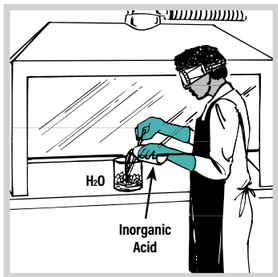
FLINN METHOD #24b continued on next page.

Flinn Method #24b, continued

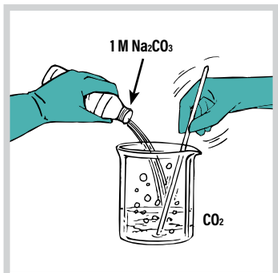
Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2. Dilute the acid by pouring it into a large beaker containing water. The final concentration of the acid should be 1 M or less.



3. Slowly add 1 M sodium carbonate solution to the diluted acid while stirring. Carbon dioxide gas will be evolved. As the acid is neutralized by the sodium carbonate, the rate of gas evolution will decrease. When further additions of sodium carbonate solution yield no gas evolution, the neutralization is complete.



4. Rinse the neutral mixture down the drain with a 20-fold excess of water.

Flinn Suggested Laboratory Chemical Disposal Methods

Flinn Scientific has been publishing suggested laboratory chemical disposal methods for more than 40 years. Each chemical in the *Flinn Scientific Catalog/Reference Manual* has a disposal number under its name. The disposal number refers to one of the suggested disposal procedures listed in this section. As federal, state and local regulations have changed, some of the disposal procedures have been updated or deleted. Before attempting any disposal procedures, it is essential that you check local regulations to determine if it is still allowed in your locale.

If you have any questions concerning laboratory waste disposal methods, please call (800-452-1261) or email (flinn@flinnsci.com).

FLINN METHOD

#25 Carbides

Calcium carbide reacts with water to generate acetylene, a highly flammable gas. Leftover calcium carbide in an experimental procedure may be decomposed with water.

Example
Calcium carbide

Materials Required
Hydrochloric acid, HCl, 3 M
Dry chemical (ABC) fire extinguisher
Glass stirring rod
Large glass beaker ¾ full of water
pH paper

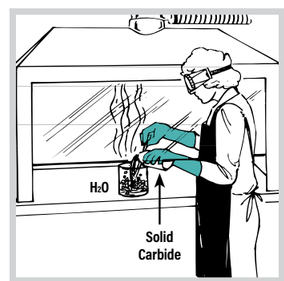
Overview
Calcium carbide reacts with water to form acetylene gas and calcium hydroxide, which is not very soluble in water. The addition of hydrochloric acid to the suspension of calcium hydroxide will dissolve it, forming water and calcium chloride. The resulting mixture should be neutralized if needed prior to drain disposal.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$
$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

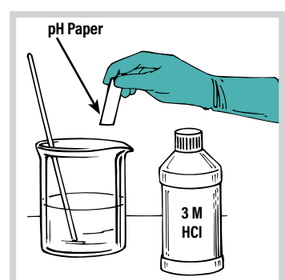
Procedure

1. Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

2. This procedure is intended for small amounts (<10 g) only! Carbides react with water, so keep these materials dry until ready for use or disposal. Slowly put the carbide granules into a large beaker of water with stirring. Flammable acetylene gas will be given off. Allow the acetylene to dissipate in the air, but avoid sources of possible ignition in the area. Allow the mixture to stand for several hours. The resulting solution will be strongly basic.



3. Using pH paper to monitor pH, neutralize the solution with 3 M hydrochloric acid.



4. Decant the neutral solution and rinse it down the drain with a 20-fold excess of water.

5. Dry any remaining solid and package it for disposal in a landfill suitable for chemical wastes.

FLINN METHOD

#26a Solid Waste Disposal in Landfill

The majority of inorganic solid wastes are salts consisting of a cation and an anion. In planning the disposal of these inorganic salts, the hazards associated with the cation and anion must be determined separately. If either part presents a potential hazard, the substance should not be disposed of in a municipal landfill.

Cations that have a relatively low level of toxicity are Al, Bi, Ca, Cu, Fe, Li, Mg, Mo(VI), K, Sc, Na, Sr, Ti, Zn and Zr. Anions that have relatively low hazards are:

Bisulfite (HSO_3^-)	Cyanate (OCN^-)	Phosphate (PO_4^{3-})
Borate (BO_3^{3-})	Hydroxide (OH^-)	Sulfate (SO_4^{2-})
Bromide (Br^-)	Iodide (I^-)	Sulfite (SO_3^{2-})
Carbonates (CO_3^{2-})	Oxide (O_2^-)	Thiocyanate (SCN^-)
Chloride (Cl^-)		

This list of less hazardous cations and anions is presented only as a guideline. Your chemical judgment, vlume of waste and local regulations must also be considered. For example, sodium hydroxide contains an acceptable cation (Na) and anion (OH), but is in fact a toxic and corrosive material that should be treated before disposal.

Materials Required
Cardboard boxes
Crumpled newspaper
Heavy tape to seal boxes

Procedure

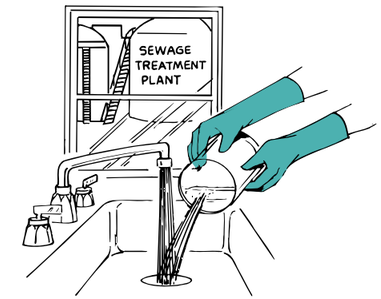
Bury solids in a landfill site approved for the disposal of chemical waste. Do not mix different materials by removing them from their separate containers because unpredictable chemical reactions may occur. Pack separate containers into sturdy cardboard boxes, separating containers from each other with crumpled newspapers to avoid inadvertent breakage. Seal the cardboard boxes with heavy tape.

This procedure is recommended for a wide array of materials, from aspirin to zinc. We use the term "landfill site approved for the disposal of chemical waste" with the full realization that many of these substances can go into the school trash. However, regulations about landfill use change with great frequency. Local regulations should be consulted about exactly what you can and cannot place in the landfill in your area. You must determine what is permitted in your area. Do not assume that it is acceptable to dump materials into the school trash. Take the time to investigate. Some instructors have made this "investigation" a student project and have learned a great deal in the process.

If you have made aqueous solutions of the water-soluble or alcohol-soluble materials classified for disposal under this procedure, we recommend that you dispose of these solutions according to Flinn Disposal Method #26b.

FLINN METHOD

#26b Waste for Drain Disposal Without Pretreatment



Aqueous solutions containing nonhazardous wastes (as defined by the EPA) may be suitable for drain disposal if—and only if—the school drains are connected to a sanitary sewer system with a water treatment plant operating on the effluent from your drains. These guidelines must be followed:

- Do not use this procedure if your drains empty into groundwater through a septic system—or into a storm sewer.*
- These materials may generally be disposed of in quantities not to exceed 100 grams each day for each substance by rinsing them down the drain with a large excess of water.
- Do not put combinations of materials down the drain at one time.

Local regulations may be more strict on drain disposal than the practices we recommend. You must determine what is permitted in your area. Sewer disposal in your community is regulated by an ordinance of your local water treatment facility. The regulations will spell out in considerable detail the allowable limits for various waste components. Because each water treatment facility is unique, you must contact the facility and get a copy of the ordinance. We also recommend meeting with representatives of the local treatment facility if a major laboratory clean-up and disposal is planned. A good working relationship with the treatment facility will make everyone more comfortable with the appropriate use of the sewer as a disposal method. For example, in some areas, compounds of aluminum, copper and zinc are not permitted in sanitary sewers. In most cases, we recommend that you substitute Flinn Disposal Method #26a for this one. All the materials recommended for this procedure are water-soluble to the extent of at least 3% and represent a very low toxicity hazard. In addition, the organic materials are readily biodegradable.

**Note:* If your drain system does not empty into a wastewater treatment facility, do not put these substances down the drain. Rather, landfill the nonflammable substances and aqueous solutions according to Flinn Disposal Method #26a, and dispose of all others using a licensed hazardous waste disposal company according to Flinn Disposal Method #26c.

Please... Read the Narratives

Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures may not be used in some jurisdictions. All procedures involve some hazards and risks. Once again... read the narratives that precede these specific chemical disposal methods.

FLINN METHOD

#27c Licensed Hazardous Waste Disposal

Many hazardous laboratory wastes require licensed hazardous waste disposal. It is important to choose a licensed and reputable firm. Please read the introduction on page 735 for more information on choosing an acceptable disposal firm. Remember that the school has cradle-to-grave responsibility for its chemicals—documented proof that the chemicals have been properly disposed is required.

- ▶ Ask for and check references to make sure the firm is reputable and reliable.
- ▶ Do not automatically choose the low bid!
- ▶ Request a certificate of disposal for the chemicals.

Prior to licensed disposal, segregate and store hazardous waste in chemically resistant containers that are free of leaks or residues. Keep containers tightly closed at all times except when adding or removing waste. Label each container "Hazardous Waste" and add the name (identity) and amounts of all chemicals added to the container, along with the accumulation start date (the date you begin collecting waste in the container). Do not mix different types of characteristic hazardous wastes as unpredictable reactions may occur, generating heat and pressure inside the container. Check the chemical computability of all chemicals added to a waste container.

FLINN METHOD

#27a Scrap Metals

Some metals may have commercial value as scrap. If you do not wish to retain them, try to sell them. Otherwise dispose of them according to Flinn Disposal Method #26a.

FLINN METHOD

#27b Mercury Metal

Procedure

Mercury metal must not be disposed of by any means except to return it to a supplier for recycling. Mercury Waste Solutions, Inc. (1-800-741-3343) is a major mercury recycler and may be a disposal option. Under no circumstances should any other method of disposal be attempted. Metallic mercury is never buried, burned, placed down a drain or otherwise put into the environment. Mercury compounds also require licensed hazardous waste disposal according to Flinn Disposal Method #27f.

FLINN METHOD

#27c Phosphorus, Red and White (Yellow)

Phosphorus is a highly reactive and very flammable material. White phosphorus is pyrophoric, a poison and ignites spontaneously in air. Red phosphorus is not pyrophoric, but it is very flammable and can react explosively with strong oxidizing agents. Both chemicals must be handled with extreme caution and disposed of by a licensed hazardous waste disposal company.

FLINN METHOD

#27d Antimony, Vanadium and Their Compounds

Antimony and its compounds are toxic and may be harmful to the environment. The vanadium compounds vanadium pentoxide and ammonium meta-vanadate are classified as P-Listed acutely hazardous toxic wastes and require licensed hazardous waste disposal. Proper management of P-Listed wastes is extremely important. Institutions that generate more than 1 kg per month (in any month) of acutely hazardous waste will be subject to the most stringent generator requirements for all their hazardous wastes. They should be disposed of properly by a licensed hazardous waste disposal company according to Flinn Disposal Method #26c.

FLINN METHOD

#27f Heavy Metals and Their Salts and Compounds

Heavy metals require licensed hazardous waste disposal. The heavy metals listed here are classified by the EPA as toxicity characteristic hazardous wastes based on the Resource Conservation and Recovery Act (RCRA). Landfill disposal of heavy metals and all of their compounds is generally prohibited and subject to strict regulatory limits for the amount or concentration of the metal or metal ion that may be disposed. The regulatory limits are defined based on a test (laboratory procedure) called the Toxicity Characteristic Leaching Procedure (TCLP). TCLP limits for the various heavy metals in this category are included in the following list. Aqueous solutions of heavy metal ions are also restricted from sewer (drain) disposal by most publicly owned treatment works (POTW). Check with your local POTW for sewer discharge limits that apply in your area. General guidelines for hazardous waste disposal are described in Flinn Disposal Method #26c.

Metal	TCLP regulatory level
Barium (Flinn Method #27h)	100 mg/L
Cadmium	1 mg/L
Chromium	5 mg/L
Lead	5 mg/L
Mercury (Flinn Method #27b)	0.2 mg/L
Silver (Flinn Method #11)	5 mg/L

FLINN METHOD

#27h Barium Compounds

Soluble barium salts are extremely toxic and are classified by the EPA as characteristic (toxic) hazardous wastes. Aqueous solutions of barium salts may be precipitated in the form of barium sulfate to reduce the volume of hazardous waste requiring disposal.

Examples

All barium salts (i.e., barium nitrate, barium hydroxide, barium chloride)

Materials Required

Sodium carbonate, Na_2CO_3
Sulfuric acid, H_2SO_4, 3 M
Filtration apparatus (optional)
Glass stirring rod
Large beaker
pH paper
Wide-mouth plastic container with screw top

Overview

Barium sulfate is highly insoluble. This procedure produces barium sulfate in an acidic solution. Note that the only acid that will work in this procedure is sulfuric acid. The acid serves a double purpose in the case of barium hydroxide and barium peroxide in that it neutralizes the hydroxide ion in addition to its primary purpose of furnishing sulfate ion to react with the barium ion. Once the precipitation reaction is complete, the solid is separated from the supernatant liquid and any excess acid is neutralized with sodium carbonate. Solid barium sulfate requires licensed hazardous waste disposal. See the general guideline in Flinn Disposal Method #26c. The neutralized supernatant should be tested for residual barium and may be rinsed down the drain with excess water.

$$Ba^{+2} + SO_4^{-2} \rightarrow BaSO_4 \text{ (solid)}$$
$$2H^+ + CO_3^{-2} \rightarrow CO_2 \text{ (gas)} + H_2O$$

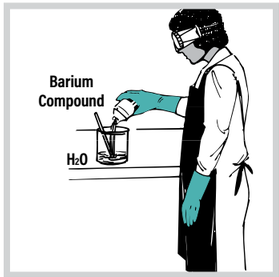
Procedure

1. Wear chemical splash goggles, chemical-resistant gloves and a lab coat or chemical-resistant apron.

FLINN METHOD #27h continued on next page.

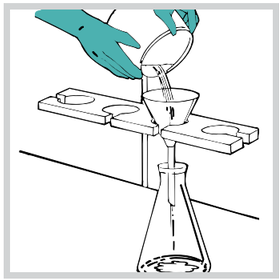
Flinn Method #27h, continued

2. Dissolve any leftover barium salt in a minimum amount of water. (Barium carbonate and barium peroxide are not soluble in water, so just suspend them in a tenfold excess of their weight in water.)

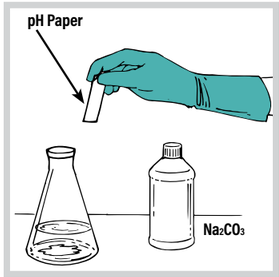


3. Add 3 M sulfuric acid to the solution while stirring until the precipitation of barium sulfate appears to be complete. Add at least a twofold molar excess of sulfuric acid.

4. Allow the precipitate to settle, and decant off the supernatant liquid or filter off the precipitate.



5. The liquid will be acidic. Using pH indicator paper, neutralize it with sodium carbonate. Check that the neutral solution does not contain residual barium, and rinse it down the drain with excess water.



6. Allow the precipitate to dry and package it for licensed hazardous waste disposal.

FLINN METHOD

#27j Halogenated Solvents

Halogenated solvents are toxic compounds. They are immiscible with water and require licensed hazardous waste disposal (see Flinn Disposal Method #26c). Most halogenated solvents are characteristic (toxic) or U-Listed hazardous wastes.

REFERENCES

The disposal procedures listed in this section are obtained from the following reliable and highly regarded sources:

ACS Task Force in Laboratory Waste Management. *Laboratory Waste Management: A Guidebook*. Washington, D.C.: American Chemical Society, 2012.

Armour, Margaret-Ann. *Hazardous Laboratory Chemicals Disposal Guide*, 3rd Edition. Boca Raton, FL: CRC Press, Lewis Publishers, 2003.

"Little Known But Allowable Ways to Deal with Hazardous Waste." EPA Publication 233-B-00-002. May 2000, accessed August 2015. http://nepis.epa.gov.

Lunn, George and Eric B. Sansone. *Destruction of Hazardous Chemicals in the Laboratory*, 3rd Edition. New York: John Wiley and Sons, 2012.

National Research Council. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. Washington, D.C.: National Academies Press, 2011.

Please… Read the Narratives

Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures may not be used in some jurisdictions. All procedures involve some hazards and risks. Once again… read the narratives that precede these specific chemical disposal methods.

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Biological Waste Disposal

Ecological studies have repeatedly demonstrated the intertwined nature of all elements of the ecosystem. A basic ecological principle simply states—"You can't do just one thing." So when we dispose of materials we are likely to do more than just dispose of the materials. When considering the disposal of any material, our goal must be to minimize the environmental impact of the disposal (i.e., come as close to doing "one thing" as possible). Common sense, a knowledge of the material and a familiarity with local disposal regulations, procedures and policies must prevail. The general guidelines provided here are only intended to stimulate clear thinking about how to minimize our effects on the environment as we recycle Earth's materials.

One important first step is to formulate a biological waste disposal policy. General guidelines and parameters should be written prior to conducting actual disposal procedures. Follwing are some suggestions that might help in formulating a general biology disposal policy:

- Contact the facilities staff for information about ongoing disposal programs.
- If applicable, get in touch with your state science supervisor or department of education. Many states have implemented clean-up campaigns in recent years. The state EPA may also have an existing program.
- Work with the state and local associations. Use the experience of other experienced instructors to help your school comply with disposal requirements.
- Seek the advice of your Environmental Health and Safety Department or that of a nearby college or university. Most large universities have ongoing waste disposal programs and understand state and local requirements.
- Contract with a licensed hazardous waste disposal firm for removing chemicals. Because the institution has cradle-to-grave responsibility for its chemicals, even after they have been removed from the site, it is vital that you choose a licensed and reputable firm. Ask for and check references, and do not automatically choose the lowest bid. Request a certificate of disposal for the chemicals.

When conducting any disposal procedures, be sure to provide personal protection for yourself and others around you. Always wear proper personal protection equipment (e.g., goggles, aprons, gloves). Conduct disposal procedures in proper areas for the materials (e.g., hoods, ventilated areas, appropriate sinks). Where appropriate, follow sterile procedures and cautions relative to potential pathogens. We have arbitrarily divided waste materials into six categories for the sake of discussion and clarity. Some situations might involve a combination of several of the categories. Specific federal, state and local regulations may apply to the disposal of biohazards from your lab. You must review your obligations and options with regulatory and school officials before developing a disposal procedure at your school.

Type I: Potentially harmful due to microorganism-type contamination
Type II: Potentially harmful due to dangerous chemical hazards
Type III: Preserved materials
Type IV: Living materials
Type V: Sharps and glass items
Type VI: Common garbage items

Type I — Potentially Harmful Wastes Due to Microorganism-Type Contamination

Biology, microbiology and biochemistry labs may generate wastes that must be managed as potentially infectious, biohazardous or regulated medical waste. Disposal of biohazardous wastes is subject to regulation by numerous authorities, including federal or state OSHA (for bloodborne pathogens), state environmental protection agencies and local wastewater treatment plants. Review the following general guidelines and essential equipment needed for the sterilization and ultimate disposal of biological wastes before planning laboratory activities involving the use of microorganisms, body fluids or recombinant DNA. Check with your state and local agencies for specific regulations regarding biohazardous waste disposal.

Examples

- Microbiological cultures and stocks, including all bacterial cultures and culture tubes
- Contaminated media and culture vessels (Petri dishes, inoculating loops) and personal protective equipment (PPE), such as disposable gloves
- Blood and other bodily or biological fluids
- Sharps and broken glass, including needles, razor or dissecting blades, glass pipets and glass tubing

. HAZARDS

It is prudent practice to treat all microbial cultures and contaminated materials as if they may cause infection or pose an environmental risk if released. Microorganisms cultured directly from the environment should NOT be incubated at temperatures higher than 25 °C, and cultures should not be opened after they have been plated on agar. After incubation, a single microbial cell may multiply to more than one million, and at that level may present a risk if a culture is broken or carelessly handled. Universal precautions for microbiological wastes, biological fluids and contaminated labware include autoclaving, dry-heat sterilization or chemical disinfection.

Disposal Procedure

Sterilization is defined as the death of all living organisms, including spores, in or on an object. Chemical disinfection with diluted household bleach is effective at killing bacteria, fungi and algae, including bacterial spores and viruses. The required concentrations and time will vary for different organisms and spores. Use only fresh household bleach, dilute 1:10 with water immediately prior to disinfection, and immerse materials for at least 6 hours (overnight is best). For increased safety using bleach disinfection, open plates while they are under solution, not in air.

Autoclaving with steam and dry heat sterilization are the preferred methods for achieving sterilization. The following materials should never be placed in an autoclave: flammable, combustible or volatile liquids and any liquid in a sealed container. Check with local authorities to determine whether autoclaved bags may be disposed of as general waste.

- Objects to be autoclaved (e.g., Petri dishes, culture tubes) should be placed into the autoclave or biohazard bags without opening the containers.
- Loosely close but do not seal the bags—steam must penetrate the materials for effective sterilization—and place then on trays inside the autoclave to capture potential spills.
- Depending on the load density, typical sterilization conditions are 30 minutes at 121 °C and 15 psi pressure. The requirements for length of autoclaving and temperature increase at higher altitudes.
- Carefully follow the manufacturer's instructions and all safety precautions, including the use of PPE.
- The use of a biological or chemical indicator, such as autoclave indicator tape, is highly recommended. Some state authorities may require periodic validation of autoclave operation using bacterial strips or cultures.
- Do not place sharp objects into an autoclave bag.

Sharp objects, such as needles, razor blades and glass pipets, must be collected in a labeled, puncture-proof container. Sharps that are contaminated with potentially hazardous biological materials or fluids should be sterilized prior to collection and/or disposal.

Type II — Potentially Harmful Wastes Due to Dangerous Chemical Hazards

Examples

Solutions from electrophoresis or staining procedures, formaldehyde solutions or other chemical solutions or solids.

. HAZARDS

Chemical wastes may be corrosive, toxic or flammable and should be handled accordingly. If the waste material is of unknown composition, assume the material is toxic, corrosive and flammable and take all precautions when handling the material. Contact Flinn Scientific for advice on how to identify and dispose of unknown chemical wastes.

Disposal Procedure

If the identity of the chemical waste is known, then consult the chemical waste disposal section of the *Flinn Scientific Catalog/Reference Manual* To find the

BIOLOGICAL WASTE DISPOSAL—TYPE II continued on next page.

proper disposal procedure, look up the chemical in the chemical section of the *Flinn Scientific Catalog/Reference Manual* and find the Flinn Suggested Disposal Procedure (e.g., Disposal: #26a) in the chemical listing. Then find the Flinn Suggested Disposal Procedure in the reference section of this manual. The disposal of chemical wastes is regulated by federal, state and local ordinances; do not perform any disposal procedure without first consulting with your local government regulatory officials.

Type III — Preserved Materials

Examples

Preserved materials used in dissection activities, such as fetal pigs, frogs and rats, either before or after dissection. Museum mount display materials.

. HAZARDS

Preserved materials are often fixed using formalin or formaldehyde. After the fixing process, the excess formaldehyde is usually removed and replaced with a nonformaldehyde preservative. The preservative solution and the preserved material both contain low levels of formaldehyde, a known carcinogen, and other chemicals. Many of these chemicals are also toxic by ingestion and inhalation.

Disposal Procedure

Do not perform this procedure if your school uses a septic system for waste water treatment. No chemicals should be placed down the drain unless your school is hooked up to a municipal water treatment facility. Prior to starting this procedure, check with your local water treatment facility for any rules or regulations concerning the disposal of formaldehyde solutions.

The first step in this disposal procedure is to rinse and wash away the preservative from the specimens. The room in which this process is undertaken should be well ventilated. Transfer the preserved specimens to a large plastic bucket or pail and place it in a large sink. Attach a length of tubing to the cold water outlet and, wearing gloves, force the exit end of the tubing into the very bottom of the bucket. If possible, use a water faucet equipped with a siphon breaker to eliminate the possibility of backflow.

Turn the water on slowly. You may want to start the water flowing before you force the tubing into the bucket to better gauge and control the water flow. A very slow but steady flow is desirable.

Allow the water to flow into the bottom of the bucket, forcing the preservative to overflow into the sink. Continue washing the specimens overnight or for a period of 10–12 hours to completely wash all preservative from the specimens.

After the wash cycle is complete, turn off the water, remove the tubing and drain all the remaining water from the container. Let the specimens drain for an hour and then double bag them in nontransparent plastic bags (black is preferred). Seal each bag completely and follow your local procedures for normal garbage disposal. Do not leave the specimens where students may find them, such as the trash can in the laboratory.

Type IV — Living Materials

Examples

Animals, such as snakes, guinea pigs, fish

. HAZARDS

Deceased living materials may contain diseases or pathogenic microorganisms that may spread to humans. Deceased animals should only be handled with gloves and disposed of as quickly as possible.

Disposal Procedure

Living animals, especially reptiles, amphibians and insects, should never be released to the environment unless first checking with local authorities. Introducing new species to your local environment may result in irreparable damage to local ecosystems.

Most areas prohibit the burial of dead animals, and you should review the local county's sanitation regulations for information on disposal of dead animals. For advice, consult your local Humane Society office, the local animal shelter, highway department or state natural resources department. A general disposal procedure is to wrap the deceased animal in newspaper, place it in a nontransparent plastic bag and then throw it in the main trash container if this is allowed. Do not leave the animal where it may be discovered by students.

Microorganism cultures, such as protozoans, should be sterilized by as outlined earlier and then flushed down the drain.

Very small dead fish can be simply flushed down the drain if the school is hooked up to a municipal water treatment facility.

Type V — Sharps and Broken Glass

Examples

Sharps and broken glass items; needles, dissecting blades, glass tubing and glass pipets.

. HAZARDS

Any sharp metal or glass object has the potential to puncture or cut the skin and deliver pathogenic organisms directly into the bloodstream in addition to creating a wound. These materials must be placed inside a hard plastic or metal container to prevent any possible physical injury.

Disposal Procedure

Check with a local hospital, health clinic or college for assistance in disposing of sharps. Hospitals and health clinics have rigorous programs to handle their sharps and may be willing to help a local school in safely disposing of sharps.

If outside help is not available, either purchase a sharps disposal container or obtain a hard plastic or metal container and add a large "sharps" label on the outside. If using a plastic container, make sure it is a hard plastic that is not flexible and cannot be easily squeezed. PET and PVC are usually better than LDPE or HDPE plastic containers. Ideally, the bottle should have a narrow neck to prevent any possibility of a student sticking hand into the sharps container. Another option is to cut a small hole in the top of the lid to allow the sharps to be added but not easily removed.

When the sharps container is full, the container and sharps must be sterilized before disposal. After sterilization, place a cap on the bottle, wrap the container in a heavy thickness of newspaper, place it in a nontransparent plastic bag and dispose of it following local disposal procedures. Never place a sharps container in a recycling bin.

Type VI — Common Garbage Wastes

Examples

Paper products, plastic laboratory wastes that are not contaminated with chemicals or biological material.

. HAZARDS

No hazards are associated with these materials beyond that of normal garbage.

Disposal Procedure

If a material has been used to dispense a chemical solution, rinse thoroughly before placing it in the trash. Dispose of all other materials that do not have chemical or biological wastes in the normal trash following your normal trash procedures. A good practice is to place disposable laboratory items in a black plastic garbage bag and then thoroughly close the plastic bag before throwing it in the trash. This may prevent laboratory items from being discovered in the trash by students and used for personal experiments or practical jokes.