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, or 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. 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 definitions for these types of waste are summarized below.) 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.

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 approx. 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 1273–1294 may frequently 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, b 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).

REVIEW OF CHEMICAL DISPOSAL PROCEDURES continued on next page.

Review of Chemical Disposal Procedures, continued

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 that the appropriate molar excess of reducing agent, as well as any acid or base needed for the reaction, will be used.

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 above.)

Source reduction, or pollution prevention, is the preferred method for reducing the environmental burden of hazardous wastes. Materials may also 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 will always 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. Hazardous waste generally falls into two categories, characteristic wastes and 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 1200 chemicals that Flinn Scientific sells, only six chemicals 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. Not all states, however, 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 will always require licensed hazardous waste disposal. Please call or e-mail 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

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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 will always 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 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 requiring 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 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 disposed. 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 the shelf life of chemicals.

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 #2).

13. **Purchase chemical demonstration kits or student laboratory kits that contain 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.

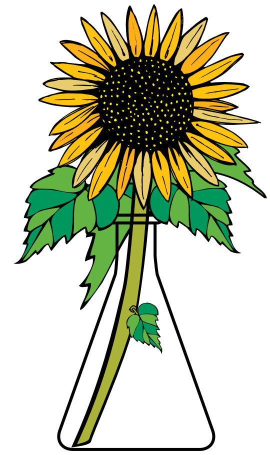
14. **Look at disposal procedures first.**
    When choosing a lab or demonstration, look at the disposal procedure first. If the disposal procedure is difficult, consider microscale techniques or substituting less hazardous materials. Avoid the use of heavy metals whenever possible.

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.

Greening the School Science Lab



For more than 35 years, Flinn Scientific has embraced a consistent philosophy regarding the use of chemicals in academic science labs: "Chemicals in any form can be safely stored, handled or used if the physical, chemical, and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed."

We still believe this philosophy is appropriate. Nevertheless, the list of banned or restricted lab chemicals continues to grow. A majority of states, for example, have banned mercury, even in thermometers. With so much negative attention on "problem" chemicals, the idea of "green chemistry" may seem like an oxymoron. Green chemistry, however, is real, and it carries a positive message about chemistry and science. The *Green Chemistry Program* was initiated by the U.S. Environmental Protection Agency in the 1990s with the goal of applying chemical principles to prevent pollution. The program calls for the design of chemical products and processes that will reduce the use and generation of hazardous substances. How can your institution benefit from the principles of green chemistry?

As your "Safer Source for Science," Flinn Scientific believes that knowledge is the most important tool we can provide to reduce waste and improve safety. We strive to provide the most reliable and helpful information possible concerning the safe purchase, storage, handling, use, and disposal of laboratory chemicals.

Basic Principles of Green Chemistry

Green chemistry presents a wonderful opportunity for science instructors to increase safety, improve science education, and impart the values and benefits of science to the next generation. The basic principles of green chemistry as they relate to academic science labs include:

- Design lab activities to avoid generating hazardous byproducts that require waste disposal.
- Substitute less hazardous and less toxic chemicals in chemical reactions or lab tests.
- Perform lab activities on a small-scale or microscale level to reduce the amounts of chemicals used.
- Use catalysts to avoid byproduct formation in chemical reactions.
- Use safer solvents.
- Avoid high temperature or high pressure conditions for chemical reactions.

> The goals of the Green Chemistry Program are embodied in the *Twelve Principles of Green Chemistry,* originally published by Paul Anastas and John Warner in 1998, which provide a roadmap for scientists to reduce and prevent pollution. The program supports fundamental research, sponsors educational and scientific outreach activities, and recognizes achievement through the *Presidential Green Chemistry Challenge Awards.* For more information about the principles of green chemistry, visit the EPA Web site at http://www.epa.gov/greenchemistry/pubs/principles.html.

Reviewing and Planning Lab Activities

To implement green chemistry, faculty and staff need to know what chemicals are being used in lab activities. This requires two things—an accurate inventory of chemicals, and a list of chemicals used in experiments and demonstrations for all lab courses. The second requirement may seem like tall order, but it is vital. After compiling this list of chemicals, most departments find that half of the chemicals in their inventory are never used! In reviewing current lab activities, carefully compare the hazards of chemicals versus the learning goals and objectives. A lab activity may use lead nitrate, for example, to precipitate lead iodide and demonstrate crystal formation. No doubt, it is a beautiful demonstration! Is the need for licensed hazardous waste disposal of the heavy metals used in this demonstration justified in terms of the learning goals? Would another demonstration accomplish the same objective? Mixing copper chloride and sodium phosphate solutions gives a turquoise solid. This reaction is "greener" and safer than lead iodide.

Set up regular department meetings to discuss some of the "not so green" lab activities in the curriculum and to share ideas for possible alternatives. Also, don't think that just because you don't have time to review every single chemical, you shouldn't do anything. Remember, a journey of a thousand miles begins with a single step. Take the first step!

Advantages of Microscale Labs

The advantages of microscale lab activities are well known—the labs are faster, so students can do more trials and gather more data, students and instructors are exposed to lower concentrations of possibly hazardous chemicals (especially for volatile substances), departments save money in the cost of chemicals, glassware, and equipment, faculty and staff spend less time setting up and cleaning up, and the amount of waste generated is greatly reduced. Many common lab activities can be reduced to the microscale level simply by combining drops of liquids in a well plate instead of mixing milliliters of liquid in a beaker.

Color the Curriculum Green!

Try the following suggestions to get started on the path to greener science labs in your school:

- Incorporate disposal treatment into the lab procedure—neutralize acid products with sodium carbonate, reduce halogen waste with sodium thiosulfate, precipitate silver ions with sodium chloride, etc.
- Purchase digital thermometers—they are safer and more precise than spirit-filled glass thermometers.
- Use lower concentrations or less hazardous forms of chemicals whenever possible.
  - –Always work with the lowest concentration possible of strong acids. If a procedure calls for 3 M hydrochloric acid, try 1 or 2 M HCl. Copper wire requires concentrated nitric acid to dissolve, but copper foil will dissolve in 6 M HNO_3.
  - –Substitute solutions for pure solids whenever possible. The LD_{50} of copper(II) chloride is 140 mg/kg—extremely toxic. Using 1 M $CuCl_2$ solution reduces the toxicity hazard almost tenfold! There is also a reduced risk of exposure to toxic fumes or dust when working with solutions.
  - –Avoid finely divided forms of metals. Granular zinc is safer than zinc dust; magnesium ribbon is safer than magnesium powder. Finally divided metals may be both a reactivity or flammability hazard (Zn, Mg) and an inhalation hazard (Pb, Cr, etc).

continued on next page

–Sodium chlorate is more stable than potassium chlorate for small-scale oxygen generation.

–Ammonium chloride is less hazardous than ammonium nitrate for endothermic solution experiments.

–Prepare bromine solutions in water (“bromine water”).

–Use methyl tert-butyl ether rather than diethyl ether for extraction procedures.

See the “Boyle’s Law in a Bottle” Student Laboratory Kit (Catalog No. AP6855) on page 457 for a description of this environmentally friendly Boyle’s law experiment.

- Perform a modern variation of the classic Boyle’s law experiment using a syringe in a special pressurized soda bottle—get rid of the mercury-filled column.
- To determine molar volume, generate hydrogen gas (from magnesium and hydrochloric acid) instead of oxygen, which requires dangerous potassium chlorate.
- Use sodium hypochlorite rather than sodium dichromate as an oxidizing agent (the latter is a carcinogen).
- For the synthesis of a coordination compound, use an iron compound instead of nickel or cobalt.
- Incorporate applications-oriented lab activities into the curriculum wherever possible to make the experiments more interesting to students while at the same time reducing the use of hazardous chemicals. Examples include acid–base titrations of fruit juices, redox reactions using Vitamin C as a reducing agent, paper chromatography of food dyes, and the preparation of biodiesel.
- Teach fundamental principles in environmental chemistry and biology.

– Determine the alkalinity or buffer capacity of water by acid–base titration.

– Use the Winkler method to measure dissolved oxygen concentrations in water as a function of nutrient levels, such as nitrate and phosphate ions.

– Compare the ability of soil versus sand to bind nutrients and exchange ions using ionic indicator dyes.

– Simulate the production and the properties of acid rain.

– Investigate how the specific heat of geological materials such as sand, soil, and water influence climate.

- Look for lab activities to teach recent advances in science and technology. Interesting kits we have developed in recent years include building a solar cell, preparing and testing biodiesel fuel made from vegetable oil, and demonstrating the properties of “colloidal gold” nanoparticles. Please consult the index to find these kits and many more!

Notice that Green Chemistry does NOT mean doing fewer labs, “dumbing down” the curriculum, or teaching less science! In fact, the opposite is true. By practicing green chemistry across the curriculum, you will be able to teach the same concepts and accomplish the same learning goals. More importantly, you will feel better knowing that you’re making a positive contribution to the environment and to science education by empowering and exciting the next generation of scientists.

Flinn ChemTopic™ Labs

Flinn Scientific has developed a series of 23 chemistry lab manuals to help you adopt a safer, “greener” attitude in chemistry labs. Created under the direction of an Advisory Board of award-winning teachers, each lab manual in the *Flinn ChemTopic™ Labs* series contains 4–6 experiments on essential concepts and applications in a single content area. Each lab manual also contains 4–6 demonstrations to capture your students’ attention. All of the lab activities were optimized to match them to the knowledge and skill level of high school chemistry. The use of hazardous reagents was critically evaluated, the preparations were scaled down, and the procedures were reviewed and optimized to make them as safe as possible while still providing satisfying outcomes. There are microscale, technology-based, and guided inquiry labs for each topic. Best of all, all of the activities were tested and retested—you know they will work! For maximum safety in choosing lab activities, try *Flinn ChemTopic™ Labs.*

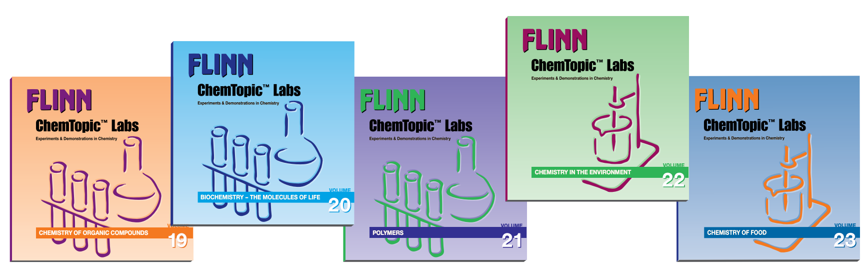
Enviromental Science Kits

See pages 1025–1058 for a complete collection of environmental biology and chemistry kits that teach fundamental principles. A few of our favorites:

Bioassay Experiment. FB1881
Copper Mining FB1913
Physical and Chemical Properties of Soil AP7184
Soil—A Natural Filter. AP7181
Specific Heat and Climate. .FB1883

Flinn ChemTopic™ Labs

“Special Topic” Lab Manuals Are Available!



Applications-oriented experiments and demonstrations guaranteed to make labs more interesting and to reduce the use of hazardous chemicals.

Catalog No.	Description	Volume No.	Price/Each
AP6987	Chemistry of Organic Compounds	19	$15.95
AP6261	Biochemistry—The Molecules of Life	20	15.95
AP6988	Polymers	21	15.95
AP6989	Chemistry in the Environment	22	15.95
AP6371	Chemistry of Food	23	15.95

See pages 1124–1127 for descriptions and complete listing of all 23 volumes in the ChemTopic Labs series.

Laboratory Chemical Disposal

- **General guidelines**
- **Chemical disposal procedures**
- **Biological disposal procedures**

The Basics of 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 1270.)

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, 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 the methods 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 will also 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 1293–1294 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 Method in this *Reference* section.

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 having 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 and 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

THE BASICS OF LABORATORY CHEMICAL DISPOSAL continued on next page.

The Basics of Laboratory Chemical Disposal, continued

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 identical 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 may also be limited by the type of septic system the school has.

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

- 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 (Cr, Pb, Ba, etc.) and halogenated solvents, will always 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 http://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 cleanup 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 35 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.

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."

Disposal Procedures

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

Materials Required

Large glass or polyethylene container
Saturated solution of sodium carbonate (200 g Na_2CO_3/L)
Stirring rod
Hydrochloric acid, HCl, 3 M
pH paper
Ice-water bath (optional)

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.

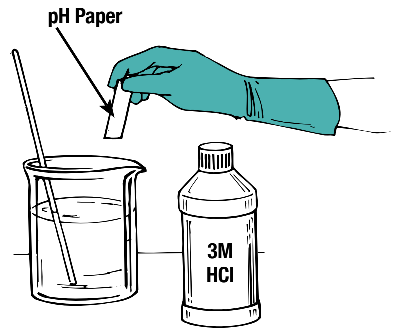
2 Place a saturated solution of sodium carbonate in a large glass or plastic container.

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.

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

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

Overview

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

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

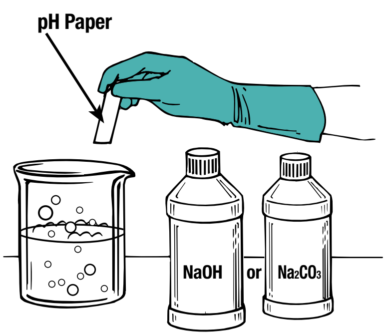
The HCl formed will dissolve in the excess water. It is neutralized with either sodium hydroxide (to form sodium chloride and water) or with sodium carbonate (to form sodium chloride, gaseous carbon dioxide and water).

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 RCRA characteristic wastes. Excess of leftover aldehyde in an experiment my be oxidized to render it nonhazardous.

Examples

Acetaldehyde and benzaldehyde

Materials Required

Beaker, 1-L
Thermometer
pH paper
Magnetic stirrer/hot plate and stir bar
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

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:

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

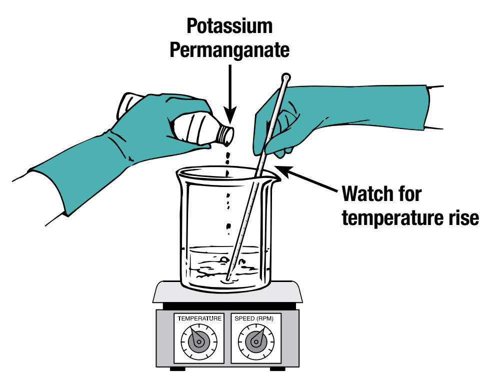
The reaction may need to be heated, and any excess permanganate should be reduced by sodium sulfite before disposal. The mole ratio is two moles of permanganate ion per mole of carbonyl group.

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.

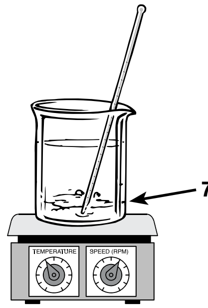


FLINN METHOD #2 continued on next page.

Flinn Method #2, continued

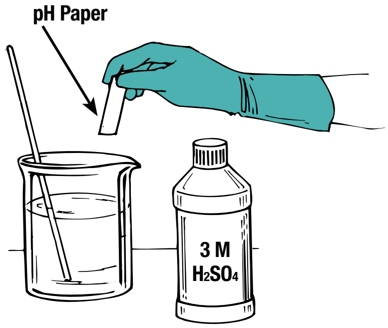
4

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



5

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.



6

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

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

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 sodium, 30 mL per g 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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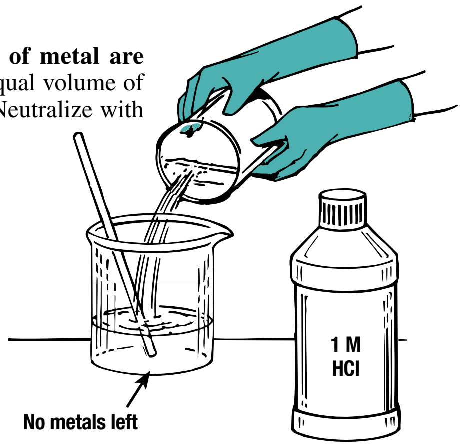
Flinn Method #3, continued

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

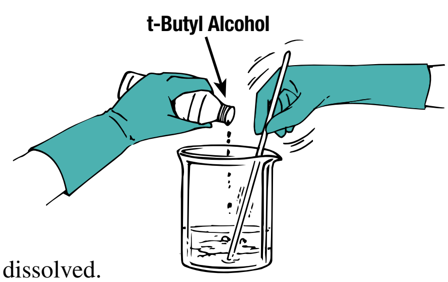
Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves, and a lab coat or chemical-resistant apron.

2b

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

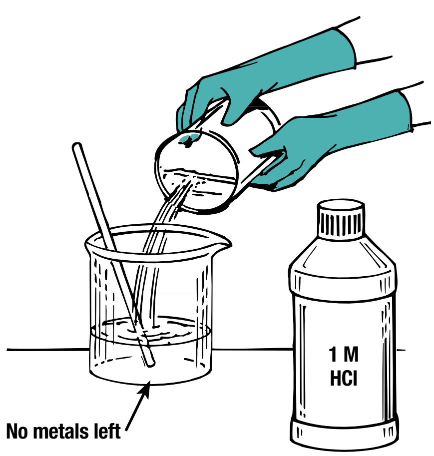
3b

Slowly add tert-butyl alcohol (at least 21 mL per g 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

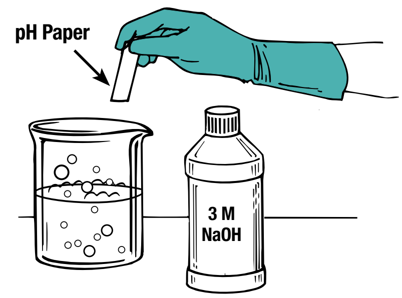
Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves, and a lab coat or chemical-resistant apron.

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 3 M sodium hydroxide.



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.

Please…Read the Narratives

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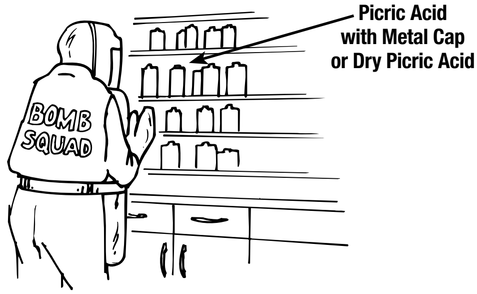
Flinn Method #4a, continued

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



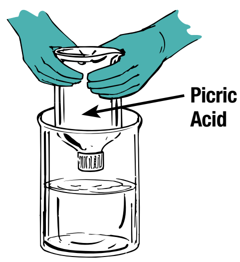
A metal-capped container of picric acid should be handled only by a trained expert such as a member of a bomb squad. Call such an expert to remove the material from the premises as soon as possible. (Picric acid can form salts with the metal in the cap and these salts are more explosive than picric acid 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
Large plastic beaker or similar container (don't use glass for HF)
Wood stirring stick
Hydrochloric acid, HCl, 3 M or sodium hydroxide, NaOH, 3 M as necessary to adjust pH
pH paper
Funnel, filter paper and flask

Procedure

1

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

2

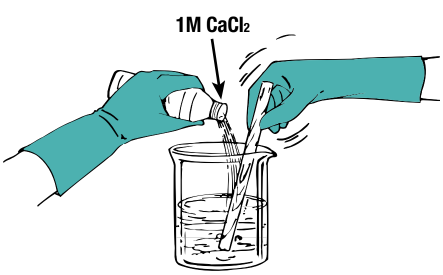
Dissolve the soluble compound (metal salt) in the smallest amount of water possible.

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.

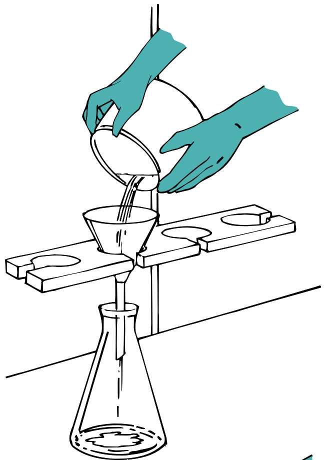


FLINN METHOD #6 continued on next page.

Flinn Method #6, continued

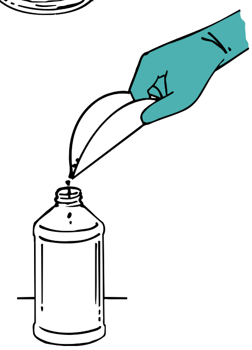
5

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 generate more than 1 kg per month (in any month) 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

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

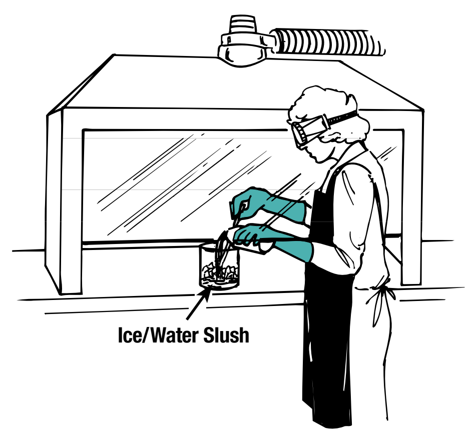
Procedure

1

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

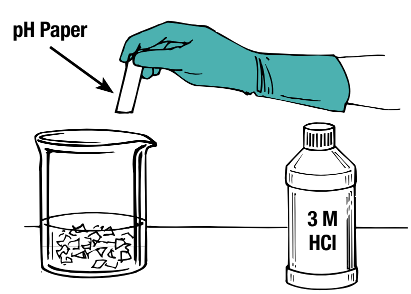
2

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

Large glass beaker
Glass stirring rod
Sodium chloride, NaCl, 1 M
Nitric acid, HNO_3, 8 M
Sodium hydroxide, NaOH, 6 M
Sucrose
Sodium hydroxide, NaOH, 2 M
Filtration apparatus
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 PbCl2 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 shown below. 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.

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

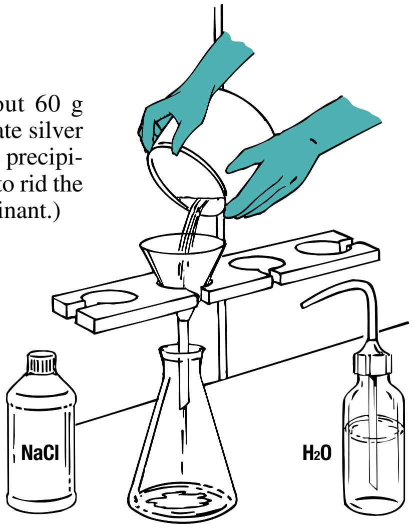
Procedure A: Silver Recovery Process

1a

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

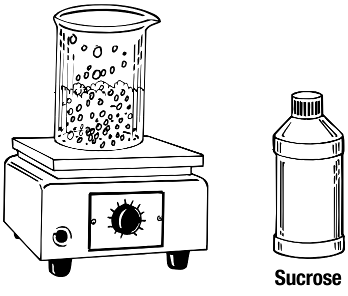
2a

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.



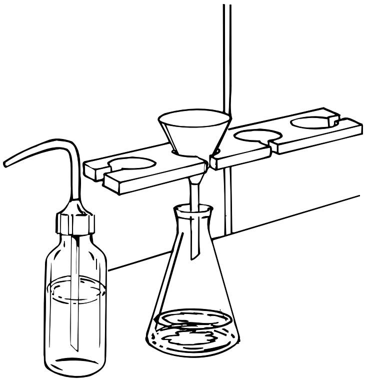
3a

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 down the drain with a 20-fold excess of 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 #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, that is, 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 thiosulfate solution, $Na_2S_2O_3$, 4%
Sulfuric acid, H_2SO_4, 1 M
Large glass beaker
Glass stirring rod
pH paper
Sodium hydroxide solution, NaOH, 1 M

Overview

Oxidizing agents by definition oxidize other substances; that is, 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 maybe 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 example below, 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.

$$3H_2O + 3S_2O_3^{-2} + 4BrO_3^- \rightarrow 6SO_4^{-2} + 4Br^- + 6H^+$$

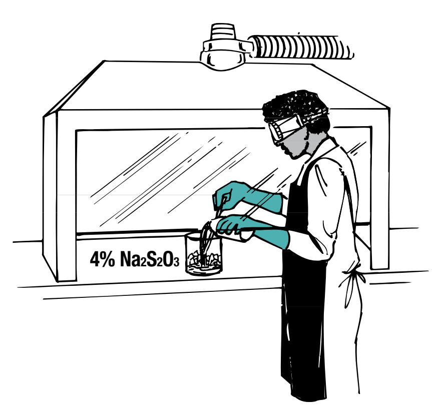
Procedure

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 #12 continued on next page.

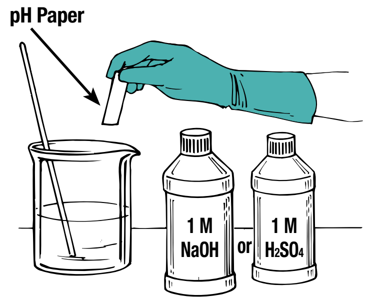
Flinn Method #12, continued

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 the above 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

Sodium carbonate, Na_2CO_3
Sodium hypochlorite solution (bleach)
Ammonium hydroxide, NH_4OH (proc. B)
Hydrochloric acid, HCl, 3 M (proc. B)
Hydrochloric acid, HCl, 1 M
Sodium hydroxide, NaOH, 1 M
Large glass beaker
Glass stirring rod
pH paper

Overview

Reducing agents by definition reduce other substances; that is, 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 below. 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

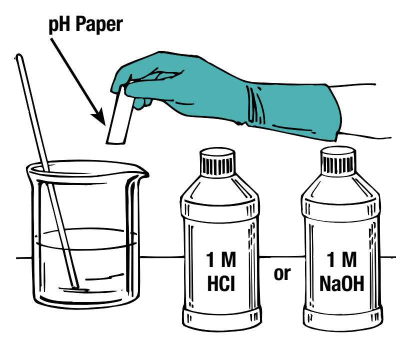
In a large beaker, dissolve an equal amount of sodium carbonate and reducing agent in distilled water.

3a

Slowly add a 25% molar excess of bleach to the mixture, the 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

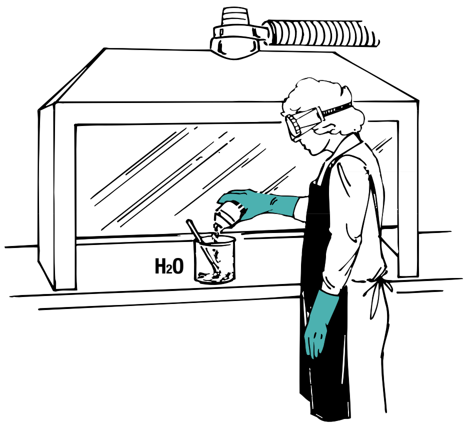
Procedure B: Nitrites

1b

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

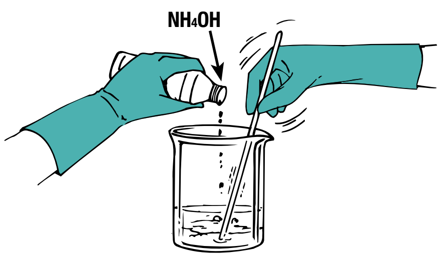
2b

Dissolve the inorganic nitrite salt in distilled water.



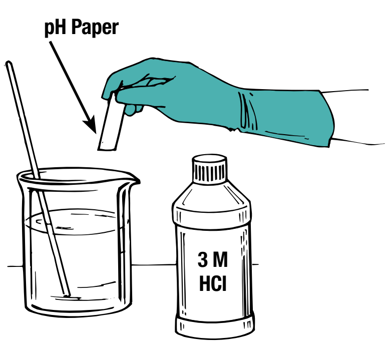
3b

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 non-toxic and are much less reactive than simple cyanide salts (see above). 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 may only 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

Large glass beaker
Glass stirring rod
Sodium hydroxide solution, NaOH, 3 M (twofold molar excess)
pH paper
Ice bath (optional)
Sodium hypochlorite solution (bleach)
Calcium hypochlorite solution, $Ca(OCl)_2$, 30%

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

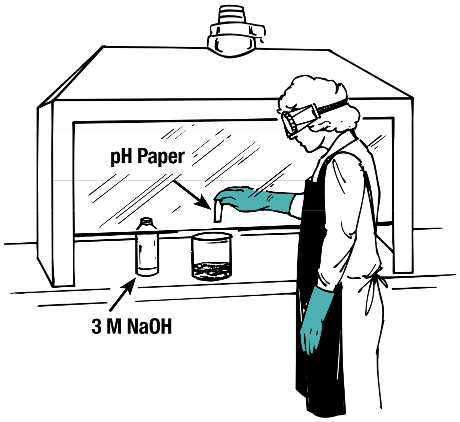
Perform this procedure in a fume hood. Wear chemical splash goggles, chemical-resistant gloves, and a lab coat or chemical-resistant apron.

FLINN METHOD #14 continued on next page.

Flinn Method #14, continued

2

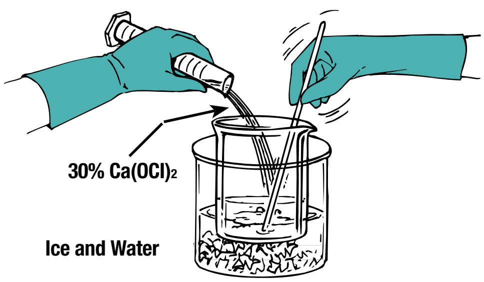
Fill a large beaker ½ full of water, and using pH paper, make it basic (at least pH 12) by adding 3 M sodium hydroxide solution, as needed.



3

Dissolve the iron cyano-complex in the water.

4



While stirring, slowly add the sodium hypochlorite solution (about 100 mL per g CN) or 30% calcium hypochlorite solution (20 mL per g CN). Heat may be evolved; maintain the temperature below 50 °C by using an ice 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.

Please…Read the Narratives

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FLINN METHOD #18a Water-Soluble Alcohols, Ketones, 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 examples below—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

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 ºC) 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

Large beaker, ¾ full of water
Plastic spoon (optional)
Plastic stirring rod
pH paper
Sodium metabisulfite, $Na_2S_2O_5$, 1 M
Hydrochloric acid, HCl, 3 M

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

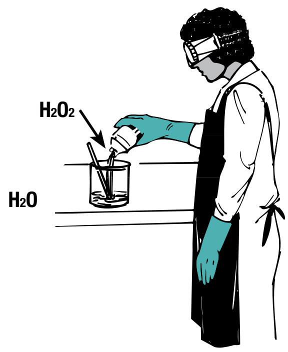
Procedure A: Water Dilution

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.

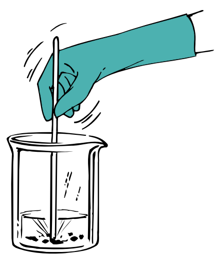


3a

When the mixture is uniform, flush it down the drain with large amounts of extra water.

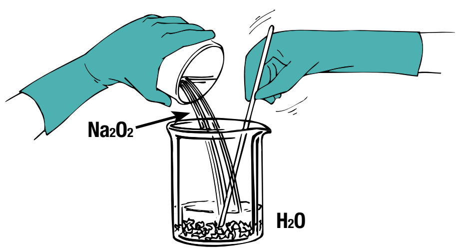
4a

If you are dealing with sodium peroxide, carefully add a small amount of water and break up any lumps with a plastic stirring rod.



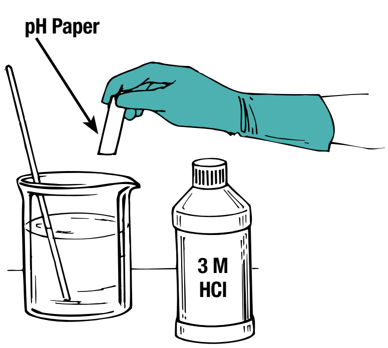
5a

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.

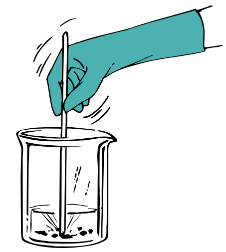
Procedure B: Reduction

1b

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

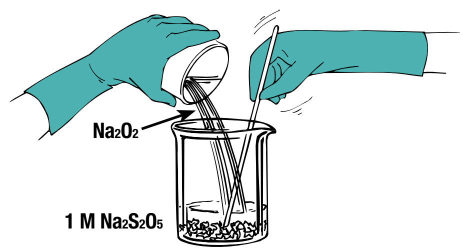
2b

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.



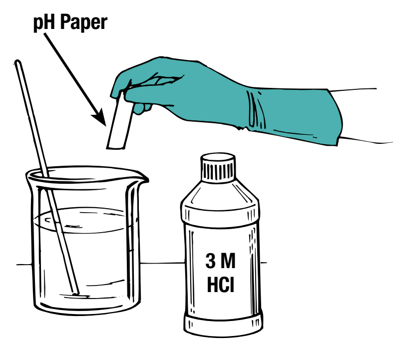
3b

Slowly add the sodium peroxide into a large beaker containing 1 M sodium metabisulfite (100 mL per g 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

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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

Sodium hydroxide solution, NaOH, 3 M—tenfold volume excess of the material to be destroyed, in a large glass beaker
Plastic spoon (optional)
Glass stirring rod
pH paper
Hydrochloric acid solution, HCl, 6 M

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.

$$(C_6H_5CO_2)_2 + 2NaOH \rightarrow 2C_6H_5CO_2^-Na^+ + O_2$$

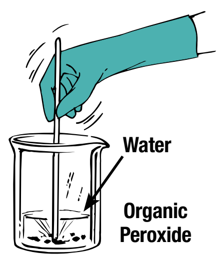
Procedure

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.

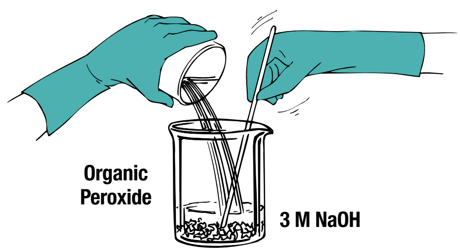
2

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.



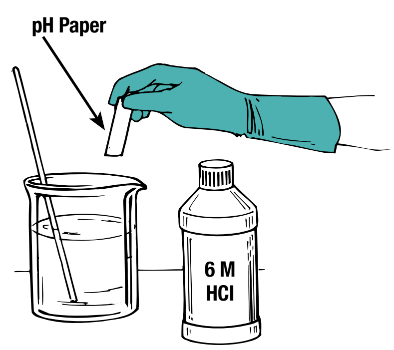
3

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

Large glass beaker
Glass stirring rod
Sodium hypochlorite solution, NaOCl
Sodium hydroxide solution, NaOH, 0.5 M

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.

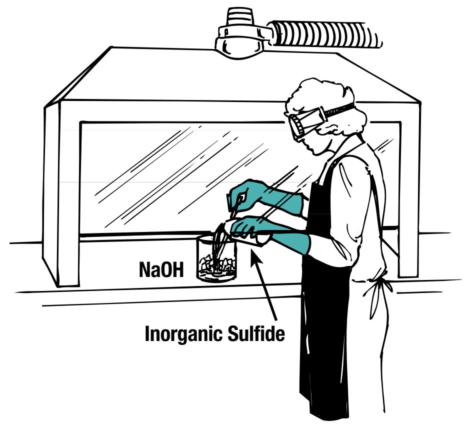
Procedure

1

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

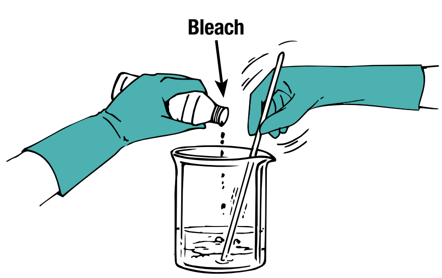
2

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 #22a, 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

Large glass beaker
Glass stirring rod
Sodium carbonate, Na_2CO_3, or sodium hydroxide solution, NaOH, 3 M
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.

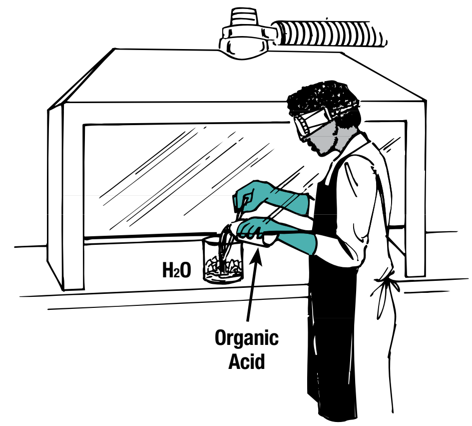
Procedure

1

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

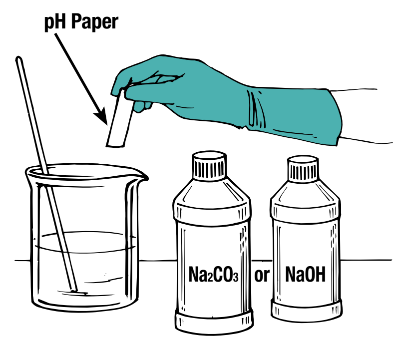
2

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

Large borosilicate glass beaker less than ½ full of water
Glass stirring rod
Sodium carbonate solution, Na_2CO_3, 1 M
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

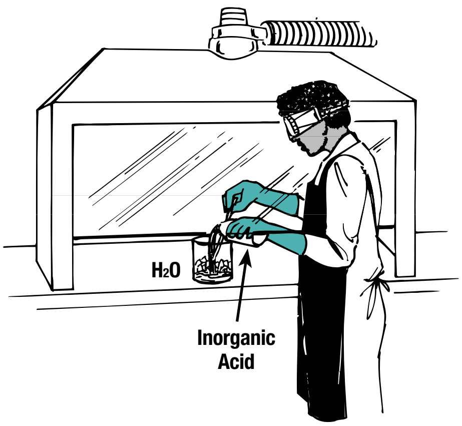
Procedure

1

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

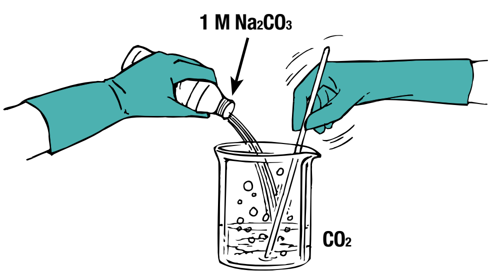
2

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



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 35 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 e-mail (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

Large glass beaker ¾ full of water
Glass stirring rod
Dry chemical (ABC) fire extinguisher
Hydrochloric acid, HCl, 3 M
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.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$
$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

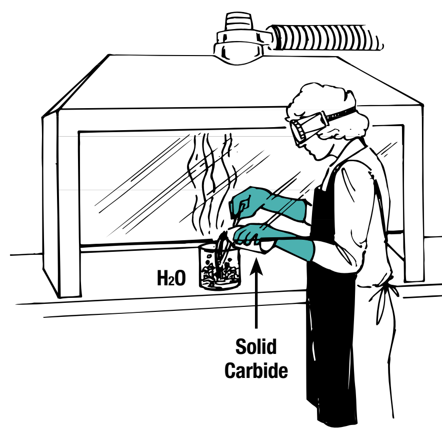
Procedure

1

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

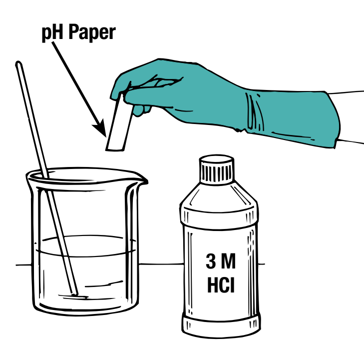
2

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, volume 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

Crumpled newspaper
Cardboard boxes
Heavy tape to seal boxes

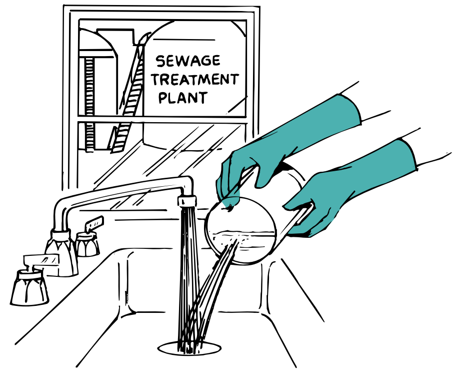
Procedure

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 as 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 (see note below).
- 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 cleanup 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 bio-degradable.

Note: If your drain system does not empty into a wastewater treatment facility, do not put these substances down the drain. Rather, landfill the non-flammable 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 #26c 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 1188 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 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 below 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 list below. 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

Large beaker
Glass stirring rod
Sulfuric acid, H_2SO_4, 3 M
Filtration apparatus (optional)
Wide-mouth plastic container with screw top
pH paper
Sodium carbonate, Na_2CO_3

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

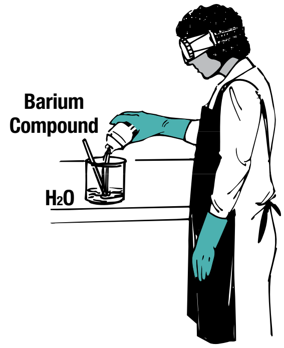
1 Wear chemical splash goggles, chemical-resistant gloves, and a lab coat or chemical-resistant apron.

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.)

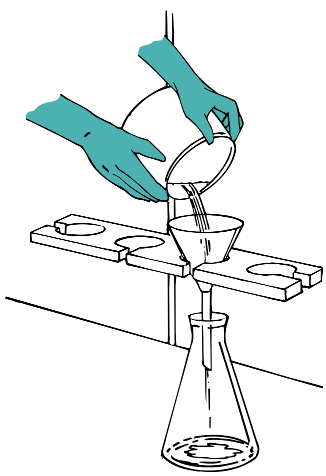


3

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.

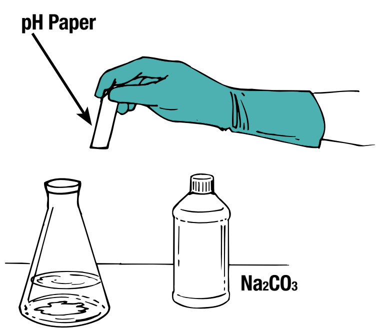
4

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:

Armour, Margaret-Ann. *Hazardous Laboratory Chemicals Disposal Guide*, 3rd Edition. Boca Raton, FL: CRC Press, Lewis Publishers, 2003.

National Research Council. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. Washington, D.C.: National Academies Press, 2011.

ACS Task Force in Laboratory Waste Management. *Laboratory Waste Management: A Guidebook*. Washington, D.C.: American Chemical Society, 2012.

Lunn, George and Eric B. Sansone. *Destruction of Hazardous Chemicals in the Laboratory*, 3rd Edition. New York: John Wiley and Sons, 2012.

"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.

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.

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. 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 cleanup 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 instructors who have faced similar issues 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 (goggles, aprons, gloves, etc.). Conduct disposal procedures in proper areas for the materials (hoods, ventilated areas, appropriate sinks, etc.). 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 is autoclaved bags may be disposed of as general waste.

- Objects to be autoclaved should be placed into the autoclave or biohazard bags without opening the containers (Petri dishes, culture tubes, etc.).
- Loosely close but do not seal the bags—steam must penetrate the materials for effective sterilization—and place the bags 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.

BIOLOGICAL WASTE DISPOSAL continued on next page.

Biological Waste Disposal, continued

★ 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 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 Chemical Disposal Procedures section of the reference 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, rats, etc., 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, etc.

★ 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 non-transparent 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 their 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 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.

Safety Tip/How To Box Index

Through our experiences, we have developed hundreds of different safety and procedural reference panels and articles. These panels and articles, many of which are illustrated, are located throughout the 2016 *Flinn Scientific Catalog/Reference Manual*. This index is by topic. If, for example, you wish to read about explosive peroxides, there are two different reference panels on pages 53 and 77. Many teachers find it a worthwhile endeavor to read all the reference panels and articles in our Catalog/Reference Manual. This index provides you with a simple means of finding references on specific topics.

A

Accident Prevention 96, 101
Acid/Base Packaging 39
Acids 32, 144, 1232–1233
  Solution Preparation 1249
Agarose Gel Preparation 893
Age, Chemicals 43
Alcohol 53, 77
  Burner Safety 134
  Denatured 77
Alconox® Dispensing 202
Algae Culture Media 982
Allergens 95
Ammeter, How to Connect 758
Anesthetizing *Drosophila* 836
ANSI Standards 1225
Aquarium
  Hard Water Problems 832
  Maintenance 829
  Setup 828
Aspirator, How to Use 160
Authorized Personnel 108
Autoclave Safety 160

B

Bacterial Culture Storage 930
Bags, Chem-Saf™ 55, 1178
Ballistics Car 599
Bases 39, 136–137
  Hazards 38
  Neutralization 122
Batteries
  Clip-Stacking 691
  Safety/Use Tips 173
Beral-Type Pipets 516
Bidding 48, 57
Binoculars 1058
Biological
  Chemicals 59
  Waste Disposal 926, 1293–1294
Blue Litmus Paper 284
Body Drench 1207
Body Tissue Irritant, Definition 100
Boiling Stones 50
Bottle Cap Safety 110
Bottles
  2-liter Soda 179
  Dropping 178
  Wash 183
Bromine 51
  Water 60
Bubble Solution 761
Buffer
  Preparation 1252
  Solutions and pH 52
Bumping Prevention 50
Burets 186–187
  Cleaning Tips 188
Burner
  Operating Tips 192
  Selection 189–190

C

Calcium Oxide 57
Cancer and Formaldehyde 80
Cans, Saf-Stor™ 55, 1178
Carbon Dioxide Preparation 232
Carcinogens 95, 109
Care for Your Hot Plate 235
Centrifuge Tubes, Safety 302
Charge, How to Apply 675
Chemical
  Contamination 37
  Disposal 1230–1233, 1270, 1273–1297
  Donations 150
  Hygiene Plan 1222–1224
  Inventory 1234–1235, 1258–1261
  Labels 240, 1214, 1219, 1238
  Packaging 1219
  Philosophy 31
  Purchase Guidelines 1219
  Resistance Plastics Chart 182
  Solution Preparation 1243–1257
  Spill Control 1241
  Storage 123
    Cleanup 1234–1235
    Fume Hood 102
    Hazards 1234–1235
    Height 140
    Pattern 1199, 1261–1265
    Why Alphabetical Order Is Bad 1267
  Stores Area Model 1266
  Theft 123
  Toxicity 1228–1229
  Transportation 41, 1232–1233
  Waste, Minimizing 1270
Chemical Abstract Service Number Explanation 29
Chemicals and Plastics, Safety Tip 176, 179
Chemicals, Lifetime Cost 48
Chemistry Is Doing 79
Chemophobia 45, 143
Chlorine Water 60
  Preparation Instructions 62
Chromatography, Paper 198
Circuit Diagrams 689
Cleaners, Laboratory 202
Cleaning Tips, Glassware 203
Clinometer, How to Use 1059
Clip-Stacking Batteries 691
Clothing, Lab 125, 1174
Colors
  Glowing Spectrum Tubes 274
Compass, Make Your Own 1059
Compatible Chemical Families 1262–1265
Containers, Chemical 57
Containment, Secondary 1175, 1232–1235
Conversion Factors 664
Cork
  Borers 206, 281
  Sizing 205
Crucibles
  Cleaning 207
  Heating 208
Culture
  Media 70, 838, 921–982
  Storage 930

D

Decanting 223
Demineralizer
  Cartridge Life 211
  Installation/Use Tip 212
Denatured Alcohol 77
Desiccants 214
Desiccator Use 213
Dialysis Tubing Preparation 899
Diluting
  Acids 32, 144
  Bases 39, 137
Disposal
  Biological Waste 1293–1294
  Chemical 1230–1233, 1270, 1273–1297
Dissolving Solids 1248
Distillation 203, 530
***Drosophila*, Anesthetizing** 836
Drying Tubes 304

E

Earthquakes, Richter Scale 1020
Eating and Drinking 112–113
Electrical Charge, How to Apply 675
Electrical Hazards and Safety 1176
Electrochemical Cell
  Porous Cup 221
  Potential Determination 220
Electrolysis Solution Preparation 710
Electrophoresis 883, 888
  Buffer Preparation 892
  Time Requirements 887
Emergency
  Plans 90
  Situations 72
Estimate Cartridge Life 211
Ether, Ethyl 76–77
Explosive Peroxides 53, 77
Extend the Life of Your Hot Plate 235
Eye Protection 38, 136
Eyewash 78, 130
  Coverage Plan 1182
  Effectiveness 1180
  Sink Adapter 1179
  Squeeze Bottle 1181
  Tester 1182

F

Filtering 223
Filter Paper 222–223
Finding Organisms in Culture 824
Fire
  Extinguisher 73, 100
    Use Plan 1183
    Use Tips 1184
  Risk Reduction 115, 1183
  Types 1184
First Aid Policy 33, 1185
Flame
  Temperature Distribution 190
  Tests 238, 275
Flaming Splints 156
Flammable
  Liquids 92, 1230–1231
  Solids 119, 131
Food in the Lab 112–113
Formaldehyde 80
  Substitutes 80
Friction 120
Fruit Flies, Anesthetic 76
Fume Hoods 102, 106, 1171, 1185
Funnels, Separatory 230

G

Gak®, How to Make 545
Gas
  Collection by
    Water Displacement 302, 304, 309
  Generator 309
  Preparation 232
Gears, Analysis 628
Glass Tubing
  and Stoppers 206
  Cutting and Fire Polishing 311
  and Stoppers 281
Glassware
  Borosilicate 174
  Cleaner Dispensing 202
  Cleaning 63, 185, 203
  Safety 63, 174, 306
Gloves
  Invisible 148, 1189
  Size Determination 1188
Goggles 74, 81, 1190, 1192–1193
  ANSI Standards 1225
  Policy 37, 47, 870, 1190, 1193, 1240
  Sanitizing 98, 234, 1193
  UV Protection 1191
Governmental Regulations 1225
Gramopak™, What Is It? 97, 139
Gram Stain 926
Grinding 247

H

Hand Cream 1189
Hand Lotion 148
Hazard Definitions 65, 95, 121
Headaches 107
Heating Liquids 50
Heavy Metals 54
Hot Plate, Extend the Life 235
Housekeeping 34
Hydrometers 236

I

Indicators, pH Ranges 88
Infusion Media Preparation 838
In-service Topics 146
Inventory, How to Take 1258–1261
Iodine 84, 89
Solution Preparation 1254

J

"Just Once" Syndrome 138

L

Labeling 35, 133, 178, 240, 1214, 1217, 1238
Laboratory
Design 1236–1237
Dress 125, 1174
Grade Chemicals 129
Laser Light, Experimentation 743
LD_{50} 130, 1228–1229
Lead 94, 143
Lethal Dose 50 .... 130, 1228–1229
Levers, Classification 625
Liability Reduction 1239–1240
Life of Your Hot Plate 235
Liquid Nitrogen, Handling/Use Hints 215
Liquid Volumes 226
Litmus Paper 284

M

Maintaining a Healthy Aquarium 829
Make Mitosis Slides 948
Maps, Mercator Projection 1014
Melting Point Determinations 305
Mercator Projection 1014
Mercury 1202
Meters, How to Connect 758
Microbiological
Spills 928
Waste Disposal 926
Microorganisms
Finding Elusive 824
Slowing 1255
Microscale
and Balances 165
Microscope
Mitosis Slides 948
Stain Cheek Cells 949
Stereoscope Setup 941
Minimizing Chemical Waste 1270
Mitosis Slides 948
Molar Volume Determination 304
Mortar and Pestle 247
Mutagens 95
Mystery Substances 35, 56
Mystic Sand 547

N

Negative Charge, How to Make 673
Neutralization 122
NFPA Code Explanation 29
Nickel Compounds 109
Nitrogen, Liquid 215

O

Odors 51
Ohm's Law 690
Organic
Chemistry, Getting Started 528
Liquids 92
OSHA 1182, 1200
Standards 34
Oxidizing Agents 120
Oxygen Preparation 114, 120, 232

P

Packaging, Chemical 57
Permissible Exposure Limits 153, 1226–1227
Peroxidizable Substances 53, 77
Petri Dish 922
pH 252
and Buffer Solutions 52, 1252
Electrode Care and Storage 251
Meter
Accuracy 250
Selection 249
Ranges, Indicators 88
Physical Constants 664
Pipeting 124, 255–256
Pipets
Beral-Type 516
Dropping 255
Plastics
and Chemicals, Safety Tip 176, 179
Chemical Resistance Chart 182
Polyethylene 178
Porous Cup 221
Positive Charge, How to Make 673
Potassium 119
Potassium Chlorate 120
Pre-lab Discussions 66
Prepare
Cheek Cells Slides 949
Dialysis Tubing 899
Mitosis Slides 948
Prep Room Setup 1253
Preservative Safety 846
Preserved Specimen Decay 852
Projection of a Spectrum 724
Protozoa Infusion Media Preparation 838
PTC Paper 284, 117
Pulleys, Analysis 626
Purchase Guidelines, Chemical 30, 1219
PVC-Coated Bottles 96

R

Radioactive Sources Safety 747
Ray Diagrams 737
Read a GHS Label Poster 44, 1203
Reagent Grade Chemicals 129
Reducing Agents 120
Refrigerators 71
Regulations, Governmental 1225
Richter Scale 1020
Right to Know Laws 1222–1224

S

Safety
Class Lesson 137
Contract 1240
Glasses 1192
Inspection 130
Posters 83, 1240
and Radioactive Sources 747
Reinforcement 37, 47, 870, 1240
Signs 1182
Simulations 68
Test 64, 66
Safety Data Sheet, How to Read 1221–1222
Sand 100
Scalpel Safety 859
Scientific Conversion Factors 664
SDS, How to Read 1221–1222
Secchi Disk, How to Use 1048
Secondary Containment 1175, 1232–1235
Seed Germination 978
Set Up an Aquarium 828
Seven-Step Plan to Clean up Your Chemical Storage Area 1234–1235
Shelf Life 43
Shelf Lips 1206
Shower, Make Your Own 1207
SI Derived Units 642
Simulations, Safety 68
Slides, Spectrum 274
Slime, How to Make 547
Smoke Generators 106
Ventilation 1186
Soap Bubble Solution 761
Sodium Hydroxide 137
Solution for Bumping 50
Solution Preparation 1243–1257
Solutions 89, 91, 1232–1233
Specific Gravity Measurement 236
Spectrum
Projection 724
Slides 274
Tube Colors 274
Spill Control 1241
Mercury 1202
Stain Cheek Cells 949
Stereoscope
Glasses, How to Use 1015
Stopcock
How to Grease 186
Plugs, Frozen 186
Stoppers 206, 281
Sizing 281
Storage, Chemical 46, 102, 140, 1262–1265
Storeroom, Chemical 108, 1234–1235, 1266
Sulfuric Acid 144

T

Tabletop Maintenance 1147
Teacher
Liability 1239
Responsibility 1239
Telescopes
Eyepieces 1013
Magnification Determination 1012
Refractor vs. Reflector 1013
Teratogens 95
Test Papers 286
Text/Lab Manual Safety 152
Thermit Reactions 147
Thermometers 289
and Stoppers 206, 281
Safety 289
Threshold Limit Values 103, 1226–1227
Toxicity
Information 65, 121, 130, 142, 1228–1229
Moderately Toxic Definition 121
Slightly Toxic Definition 65
Training, Teacher 126
Transporting Chemicals 41, 1232–1233
Tubing, Choosing 312
Turbidity Determination 1048

U

Unknown Chemicals 35, 56
UN Number Explanation 29
UV Protective Eyewear 1191

V

Vacuum
Filtration 227
Pump 262
Ventilation 107, 1230–1231
Smoke Generators 1186
Voltmeter, How to Connect 758

W

Wash Bottles 183
Water
and pH 211, 218
Aspirator, How to Use 160
Distilled or
Demineralized 211, 213, 1248
Water-Reactive Metals 119, 131
Working Alone 128