The Dos and Don'ts of Chemical Labeling

Information on What's Required to Make Your Lab Safe

At a recent chemistry meeting, a question came up concerning the proper method of labeling a chemical container. Of the 24 chemistry teachers in attendance, not one of them was sure what kind of information is required on a chemical label.

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

At the time, the only guideline for labeling was that the label must list the "appropriate hazard warnings." In 1994, OSHA clarified their position and said that a label must include "the specific physical or health hazard(s) including target organs affected."

OSHA also realized that labels may not be large enough to list every possible warning so they said the label should provide a brief summary of the hazards in a highlighted form. When a teacher or student needs in-depth information, they should refer to the Material Safety Data Sheet.

Based on what we now know, how should a chemical container or bottle be labeled? We suggest the best approach to proper chemical container labeling is to list these four items on the label.

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



Chemical Labeling Software

Print informative chemical labels within seconds. Perfect for chemical solution containers or student reagent bottles. Database contains over 1000 chemical labels with the ability to customize your own label. Meets Right to Know standards.

The label format shows:

- Chemical Name
- Concentration
- Flinn Storage Code Number
- Hazard Warnings
- Date Prepared
- CAS Number
- NFPA Code

Catalog No.	Description	Price
SE2553	Chemical Labeling Software	$35.95

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

Hydrochloric acid
6M solution
Corrosive to all body tissue, especially skin and eyes.
Avoid all body contact.
2001

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

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

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

How to Read an MSDS

Material Safety Data Sheets (MSDS) are an important component of OSHA Hazard Communication Standard. MSDS have become an important document to inform employees, students, and the general public how materials can be safely handled, used, and stored. Since Flinn only provides chemicals to schools, we have written Flinn MSDS specifically for teachers and their students. Using clear and straightforward language, each Flinn MSDS provides all the relevant safety and hazard information in a consistent, useful, and easy-to-read two-page format. Flinn MSDS follow the American National Standards Institute (ANSI) and Chemical Manufacturer Association (CMA) 16-section MSDS format which exceeds OSHA requirements. The 16 sections are divided into four major areas, each designed to answer a specific question.

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

Sections 1–3.

1 Important that the chemical name on the label matches the name on the MSDS. Many chemicals have similar names, but very different properties.

2 The CAS# is the single identifying number for each specific substance. CAS# should match the CAS# on the bottle label.

3 The most important section! The first part describes the material's appearance. If it doesn't look like this, STOP. Do not use it. It may be more or less hazardous.

The second part provides an overview of the most significant and immediate concern when using this material. It will include reactivity, adverse health effects, and flammability information.

4 Flinn At-A-Glance™ provides a numerical guide in five categories. If 2's and 3's are present, read the MSDS for further information.

What should I do if a hazardous situation occurs?

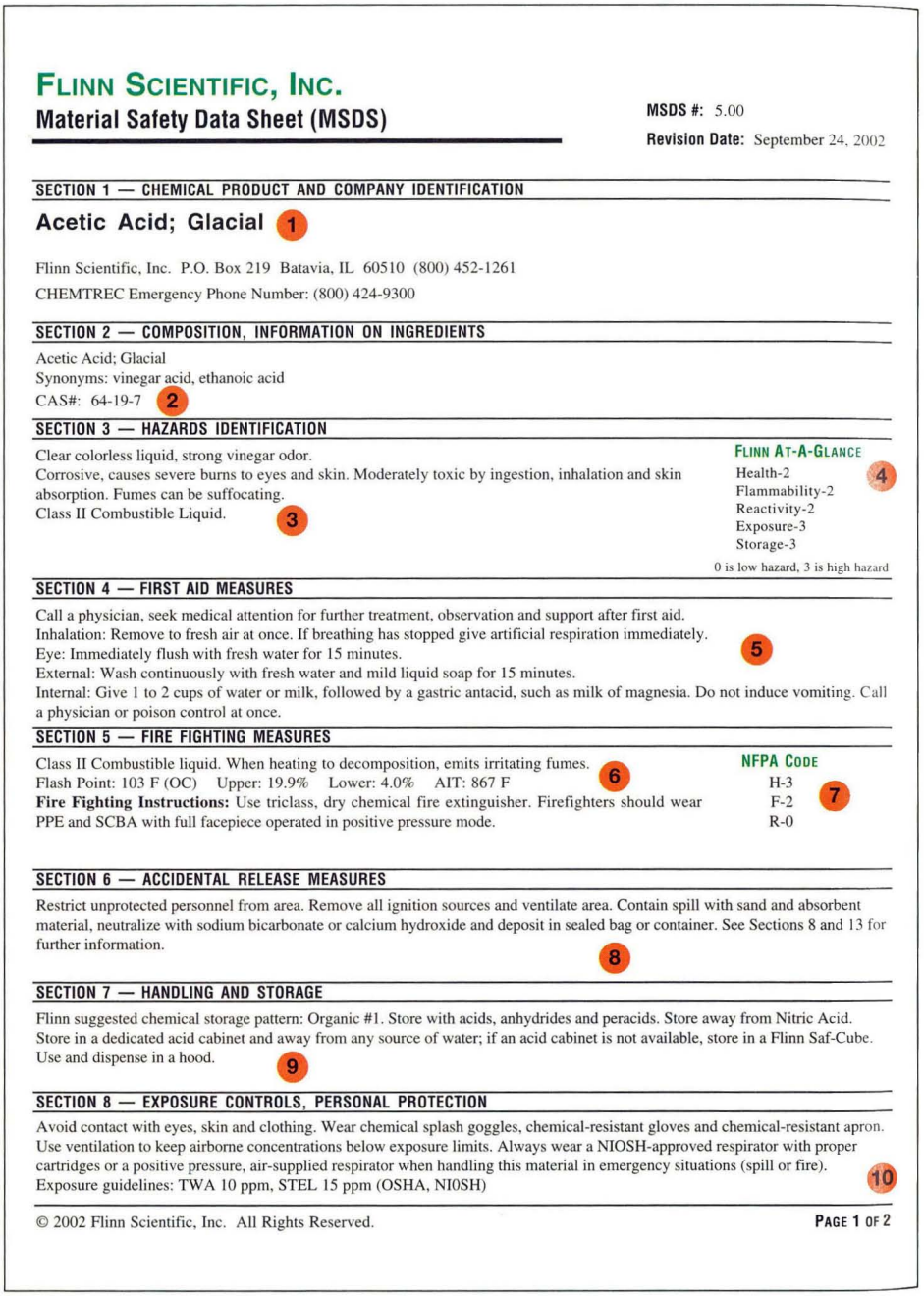
Sections 4–6.

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

6 This section is written for the firefighter. Flash point (the lowest temperature at which enough vapor is present for an ignitable mixture); upper and lower flammable limits; and the auto ignition temperature (AIT) are common values included.

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

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



FLINN SCIENTIFIC, INC.

Material Safety Data Sheet (MSDS)

MSDS #: 5.00

Revision Date: September 24, 2002

SECTION 1 — CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Acetic Acid; Glacial 1

Flinn Scientific, Inc. P.O. Box 219 Batavia, IL 60510 (800) 452-1261

CHEMTREC Emergency Phone Number: (800) 424-9300

SECTION 2 — COMPOSITION, INFORMATION ON INGREDIENTS

Acetic Acid; Glacial

Synonyms: vinegar acid, ethanoic acid

CAS#: 64-19-7 2

SECTION 3 — HAZARDS IDENTIFICATION

Clear colorless liquid, strong vinegar odor.

Corrosive, causes severe burns to eyes and skin. Moderately toxic by ingestion, inhalation and skin absorption. Fumes can be suffocating.

Class II Combustible Liquid. 3

FLINN AT-A-GLANCE 4

Health-2
Flammability-2
Reactivity-2
Exposure-3
Storage-3

0 is low hazard, 3 is high hazard

SECTION 4 — FIRST AID MEASURES

Call a physician, seek medical attention for further treatment, observation and support after first aid.

Inhalation: Remove to fresh air at once. If breathing has stopped give artificial respiration immediately.

Eye: Immediately flush with fresh water for 15 minutes. 5

External: Wash continuously with fresh water and mild liquid soap for 15 minutes.

Internal: Give 1 to 2 cups of water or milk, followed by a gastric antacid, such as milk of magnesia. Do not induce vomiting. Call a physician or poison control at once.

SECTION 5 — FIRE FIGHTING MEASURES

Class II Combustible liquid. When heating to decomposition, emits irritating fumes.

Flash Point: 103 F (OC) Upper: 19.9% Lower: 4.0% AIT: 867 F 6

Fire Fighting Instructions: Use triclass, dry chemical fire extinguisher. Firefighters should wear PPE and SCBA with full facepiece operated in positive pressure mode.

NFPA CODE 7

H-3
F-2
R-0

SECTION 6 — ACCIDENTAL RELEASE MEASURES

Restrict unprotected personnel from area. Remove all ignition sources and ventilate area. Contain spill with sand and absorbent material, neutralize with sodium bicarbonate or calcium hydroxide and deposit in sealed bag or container. See Sections 8 and 13 for further information. 8

SECTION 7 — HANDLING AND STORAGE

Flinn suggested chemical storage pattern: Organic #1. Store with acids, anhydrides and peracids. Store away from Nitric Acid. Store in a dedicated acid cabinet and away from any source of water; if an acid cabinet is not available, store in a Flinn Saf-Cube. Use and dispense in a hood. 9

SECTION 8 — EXPOSURE CONTROLS, PERSONAL PROTECTION

Avoid contact with eyes, skin and clothing. Wear chemical splash goggles, chemical-resistant gloves and chemical-resistant apron. Use ventilation to keep airborne concentrations below exposure limits. Always wear a NIOSH-approved respirator with proper cartridges or a positive pressure, air-supplied respirator when handling this material in emergency situations (spill or fire). Exposure guidelines: TWA 10 ppm, STEL 15 ppm (OSHA, NI0SH) 10

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How can I prevent hazardous situations from occurring?

Sections 7–11.

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

10 Wear personal protection equipment such as goggles, gloves, and an apron. See page 928 for an explanation on TWA and STEL.

HOW TO READ AN MSDS continued on next page.

HOW TO READ AN MSDS, continued

Each Flinn MSDS follows the same format and the data is always found in the same location making it a valuable resource in the event of an emergency. Flinn sends an MSDS with every chemical you order. Flinn MSDS are continually updated, guaranteeing the most up-to-date safety information possible. Flinn sells a complete MSDS library in two versions, a hard copy version in two binders or an electronic version on a CD-ROM. For a more detailed description of our MSDS Library, please refer to pages 908–909. For our customers' convenience, Flinn has placed a complete set of MSDS on our website. Simply go to www.flinnsci.com and click on the safety icon—individual MSDS are easy to find and very easy to print out on your printer.

FLINN SCIENTIFIC, INC.
Material Safety Data Sheet **Acetic Acid; Glacial**

MSDS #: 5.00
Revision Date: September 24, 2002

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

Clear colorless liquid with strong 'vinegar' odor
Solubility: Soluble in water.
Freezes at slightly below room temperature (17 C).
Formula: CH3CO2H
Formula Weight: 60.5

11

Melting Point: 16.2 C
Boiling Point: 244 F
Vapor Density: 3.52
Vapor Pressure: 11 mm and 20 C
Concentration: 17.4 molar; 36-37%

SECTION 10 — STABILITY AND REACTIVITY

Avoid contact with strong oxidizers, especially chromic and nitric acids.
Shelf Life: Indefinite, if stored properly.

12

SECTION 11 — TOXICOLOGICAL INFORMATION

Acute effects: Harmful liquid, corrosive
Chronic effects: N.A.
Target organs: N.A.

13

ORL-RAT LD50: 3310 mg/kg
IHL-RAT LC50: 5620 ppm/1H
SKN-RBT LD50: 1060 mg/kg

14

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

SECTION 12 — ECOLOGICAL INFORMATION

Data not yet available.

15

SECTION 13 — DISPOSAL CONSIDERATIONS

Please consult with state and local regulations.
Flinn Suggested Disposal Method #24a is one option.

16

SECTION 14 — TRANSPORT INFORMATION

Shipping Name: Acetic Acid, Glacial
Hazard Class: 8, Corrosive, Flammable liquid
UN Number: UN2789
N/A = Not applicable

17

SECTION 15 — REGULATORY INFORMATION

TSCA-listed, EINECS-listed (200-580-7). RCRA code D001, D002

18

SECTION 16 — OTHER INFORMATION

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

19

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

FLINN SCIENTIFIC INC.
"Your Safer Source for Science Supplies"
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How can I prevent hazardous situations from occurring? (continued)

11 Clear, concise, and useful physical and chemical properties help you learn more about the chemicals you use. Formula and formula weight are also useful for making solutions.

12 Describes the conditions or reactions to be avoided. Also provides some indication about anticipated shelf life.

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

14 Oral (ORL), inhalation (IHL), and skin absorption (SKN) toxicity data on test animals is included. For more information on LD_{50} and LC_{50}, see page 930.

Other useful information.
Section 12–16.

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

16 Suggested disposal methods for disposing laboratory quantities of chemicals. See pages 973–1005 for Flinn Suggested Disposal Methods.

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

18 Regulatory information used by regulatory compliance personnel.

19 Flinn Scientific has an ongoing program to update its MSDS. As professional chemists, we try our best to provide science teachers with the most accurate and useful safety information.

20 Call Flinn if you have any questions. We can help!

Chemical Exposure

When Are Vapors Harmful To You and Your Students?



Threshold Limit Values (TLV) and Permissible Exposure Limits (PEL) refer to the level of a chemical above which a person should avoid repeated and prolonged exposure. TLVs and PELs were originally structured to provide guidelines for workers in industry who are repeatedly exposed to the same chemicals day after day. Science teachers can use these values to provide guidance on which chemicals to use and when to take precautions. TLVs and PELs are very general standards since every individual responds differently to exposure. The amount of exposure and the time period of exposure are the critical issues.

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

TLVs for vapor or gas are reported as parts per million (ppm) or milligrams per cubic meter (mg/m^3) of air. A cubic meter is approximately the size of a small telephone booth. Dust, particulate matter, or mist are reported only as milligrams per cubic meter of air.

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

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

The threshold of smell of many chemicals is usually below that of the TLV. Strong smell may act as a warning that the TLV is being approached. Since human smelling ability can be impaired by some odors, one should not depend on smell as a reliable indicator of a hazard. Chlorine gas, as an example, has a TLV of 0.5 ppm or 1.5 mg/m^3. Your odor threshold for chlorine is likely to be 0.3 ppm. If you can smell it, you are probably at or near the level of concern.

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

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

1. **Ventilation.** Ventilation of the school science laboratory should be of paramount importance to the science teacher. Two types of ventilation should be incorporated in the science laboratory. A purge ventilation system (see page 919) should be available to provide a quick air exchange in the laboratory whenever the level of hazardous chemical vapors or dust approaches the TLV. Also, fume hoods should be available and used whenever volatile and hazardous materials are used. A reaction that is performed in a properly operating fume hood will not release any vapors into the laboratory.
2. **Substitution.** Use the TLV table on the following page to substitute a less hazardous chemical for the experiment or activity. For example, if an alcohol is required for an experiment and methyl, ethyl, or isopropyl alcohol can be used, the smart choice is to use ethyl alcohol because it has the highest TLV. Another example is melting point determinations. Many teachers have used naphthalene or para-dichlorobenzene, both of which have a TLV of 10 ppm. Why not substitute a less hazardous material such as cetyl alcohol, stearic acid, or t-octyl phenol?
3. **Microscale.** Scaling down the quantity of material used will reduce the amount that can volatilize into the atmosphere. If a typical class (15 lab groups, 280 m^3 room) performs a lab where sulfur is burned to form sulfur dioxide and the lab is microscaled to use only 0.05 g of sulfur, the average level of sulfur dioxide in the room would not exceed 3 mg/m^3, below the TLV of 5.2 mg/m^3. However, if 0.2 g or more are used by each group, the TLV would quickly be exceeded.

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

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

CHEMICAL EXPOSURE continued on next page.

Some Common Chemical TLVs

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

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

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

A RESPONSIBLE TEACHER WILL USE A HOOD!

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

"How Toxic Is Toxic?"

Any substance can be harmful to living organisms. However, it is the dose that frequently determines the extent of the damage. Many other factors including time of exposure, route of exposure, age, sex, lifestyle, allergic factors, previous sensitization, and genetic disposition may impact the overall effect that a chemical has on an organism. Toxicologists have developed several tools to determine the toxicity of chemicals. Acute toxicity, which is the immediate effect of a substance as a result of a single dose, is relatively easy to study. Chronic toxicity results from low doses repeated over long periods of time and is much more difficult to test.

Toxicologists use LD_{50} values to estimate the acute toxicity of chemicals on humans. LD means the lethal dose and is expressed in milligrams of chemical per kilogram of body weight. The species of the test animal (rats, etc.) and how the substance was administered (oral, injection, skin absorption) are usually included in the LD_{50} statement. The 50 in LD_{50} is the mortality rate (50%) of the test animal and is calculated from a dose-mortality curve. A typical toxicology statement reads as follows:

Aniline LD_{50} oral-rat: 250 mg/kg

and can be interpreted as a single oral dose of 250 mg/kg will kill 50% of a test sample of rats.

It should be noted that no LD_{50} data exists for humans. Data from test animals is used to estimate the acute toxicity of chemicals on humans. Toxicity data should be used to understand the relative toxicity of chemicals and which chemicals may require greater precautions when handled. The lower the LD_{50} the more toxic the substance. The chart below provides LD_{50} data for many items listed in the *Flinn Scientific Catalog/Reference Manual*. Please note that LD_{50}s do not exist for many chemicals, including some hazardous chemicals (e.g., lead compounds).

Substance	LD_{50} Oral—rat per kilogram
Acetaldehyde	661 mg
Acetamide	7000 mg
Acetanilide	800 mg
Acetic Acid	3310 mg
Acetic Anhydride	1780 mg
Acetone	5800 mg
Acetyl Salicylic Acid	200 mg
Adenine	745 mg
Aluminum Chloride	3310 mg
Aluminum Nitrate	3671 mg
Ammonium Chloride	1650 mg
Ammonium Hydroxide	350 mg
Ammonium Molybdate	333 mg
Ammonium Nitrate	2217 mg
Ammonium Persulfate	689 mg
Ammonium Sulfate	2840 mg
Ammonium Thiocyanate	750 mg
Amyl Acetate	6500 mg
n-Amyl Alcohol	2200 mg
Aniline	250 mg
Aniline Hydrochloride	840 mg
Antimony	7000 mg
Antimony Trichloride	525 mg
Arsenic Trioxide	15.1 mg
Barium Acetate	921 mg
Barium Carbonate	418 mg
Barium Chloride	118 mg
Barium Nitrate	355 mg
Benzaldehyde	1300 mg
Benzene	4894 mg
Benzoic Acid	1700 mg
Benzoin	10000 mg
Benzoyl Peroxide	7710 mg
Benzyl Alcohol	1230 mg
Benzyl Benzoate	500 mg
Bismuth	5000 mg
Bismuth Nitrate	4042 mg
Boric Acid	2660 mg
Bromobenzene	2699 mg
Bromoform	1147 mg
n-Butyl Alcohol	790 mg
sec-Butyl Alcohol	6480 mg
tert-Butyl Alcohol	3500 mg
Butyl Phthalate	8000 mg
Butyric Acid	2000 mg
Cadmium	225 mg
Cadmium Chloride	88 mg
Cadmium Nitrate	305 mg
Caffeine	192 mg
Calcium Chloride	1000 mg
Calcium Fluoride	4250 mg
Calcium Hydroxide	7340 mg
Calcium Hypochlorite	850 mg
Calcium Nitrate	3900 mg
Carbon Disulfide	3188 mg
Carbon Tetrachloride	2800 mg
Cesium Chloride	2600 mg
Cetyl Alcohol	5000 mg
Chloroform	908 mg

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

Substance	LD_{50} Oral—rat per kilogram
Chromium(ic) Chloride	1790 mg
Chromium(ic) Nitrate	3250 mg
Chromium Trioxide	80 mg
Cinnamaldehyde	2220 mg
Citric Acid	11700 mg
Cobalt Carbonate	640 mg
Cobalt(ous) Chloride	766 mg
Cobalt(ous) Nitrate	691 mg
Cobalt Oxide	5000 mg
Cobalt(ous) Sulfate	768 mg
Colchicine	6 mg
Crystal Violet	420 mg
Cupric Acetate	710 mg
Cupric Carbonate	1350 mg
Cupric Chloride	140 mg
Cupric Nitrate	940 mg
Cupric Sulfate	300 mg
Cuprous Chloride	140 mg
Cuprous Oxide	470 mg
Cyclohexane	12705 mg
Cyclohexanol	2060 mg
Cyclohexene	2300 mg
2,6-Di-t-Butyl-4-Methyl Phenol	890 mg
p-Dichlorobenzene	500 mg
2,4-Dichlorophenoxy Acetic Acid	375 mg
Diisopropanolamine	6720 mg
1,4 Dioxane	5700 mg
Diphenylamine	300 mg
Dodecyl Alcohol	12800 mg
Ethyl Acetate	6100 mg
Ethyl Alcohol	7060 mg
Ethyl Ether	1215 mg
Ethylene Diamine	500 mg
Ethylene Dichloride	670 mg
Ethylene Glycol	4700 mg
Ferric Chloride	1278 mg
Ferric Nitrate	3250 mg
Ferrous Sulfate	1520 mg
Formaldehyde	100 mg
Formic Acid	1100 mg
Fumaric Acid	10700 mg
Glutaraldehyde	134 mg
Glycerin	12600 mg
Hexamethylenediamine	750 mg
Hexanes	28710 mg
Hexyl Alcohol	720 mg
Hydroquinone	320 mg
Hydroxylamine Hydrochloride	408 mg
Indigo Carmine	2000 mg
3-Indole Butyric Acid	100 mg
Iodine	4000 mg
Isobutyl Alcohol	2460 mg
Isopropyl Alcohol	5045 mg
Isopentyl Alcohol	1300 mg
Lactic Acid	3730 mg
Lauric Acid	12000 mg
Lithium Carbonate	525 mg

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

"HOW TOXIC IS TOXIC?" continued

Substance	LD_{50} Oral—rat per kilogram
Lithium Chloride	526 mg
Lithium Sulfate	1190 mg
Magnesium Chloride	2800 mg
Magnesium Nitrate	5440 mg
Malachite Green Oxalate	275 mg
Maleic Acid	708 mg
Maleic Hydrazide	3800 mg
Malonic Acid	1310 mg
Manganous Chloride	1984 mg
Menthol	3180 mg
Mercuric Chloride	1 mg
Mercuric Iodide	40 mg
Mercuric Nitrate	26 mg
Mercuric Oxide	18 mg
Mercuric Sulfate	57 mg
Mercurous Chloride	166 mg
Mercurous Nitrate	170 mg
Mercurous Sulfate	152 mg
Methyl Alcohol	5628 mg
Methyl-t-Butyl Ether	3865 mg
Methyl Ethyl Ketone	2737 mg
Methyl Isobutyl Ketone	2080 mg
Methyl Methacrylate	7872 mg
Methyl Orange	60 mg
Methyl Salicylate	887 mg
Methyl Violet	413 mg
Methylene Blue	1180 mg
Methylene Chloride	1600 mg
Napthalene	490 mg
1-Napthol	1870 mg
Nickel(ous) Chloride	105 mg
Nickel(ous) Nitrate	1620 mg
Nickel(ous) Sulfate	275 mg
Nicotine	50 mg
para-Nitrophenol	250 mg
1-Octadecanol	20000 mg
1-Octanol	1790 mg
4-(t-Octyl) Phenol	3210 mg
Orcinol	844 mg
Oxalic Acid	375 mg
Perchloroethylene	1100 mg
1,10-Phenanthroline	132 mg
Phenol	384 mg
1,4-Phenylenediamine	80 mg
Phenyl Salicylate	3000 mg
Phenyl Thiocarbamide	3 mg
Phosphoric Acid	1530 mg
Phosphorous, Yellow	1.4 mg
Phosphorous Pentoxide	660 mg
Phthalic Anhydride	4020 mg
Potassium Bisulfate	2340 mg
Potassium Bromate	321 mg
Potassium Carbonate	1870 mg
Potassium Chloride	2430 mg
Potassium Chromate	180 mg
Potassium Cyanide	10 mg
Potassium Dichromate	190 mg
Potassium Ferricyanide	1600 mg
Potassium Ferrocyanide	3613 mg
Potassium Fluoride	245 mg
Potassium Hydroxide	273 mg
Potassium Iodate	531 mg
Potassium Nitrate	3750 mg
Potassium Nitrite	200 mg
Potassium Permanganate	1090 mg
Potassium Persulfate	802 mg
Potassium Phosphate, Tribasic	1450 mg
Potassium Thiocyanate	854 mg
Propionic Acid	2600 mg
n-Propyl Alcohol	1870 mg
Pyridine	891 mg
Pyrogallol	300 mg
Resorcinol	301 mg
Rhodamine B	887 mg
Salicylic Acid	891 mg
Silver Nitrate	50 mg
Silver Oxide	2820 mg
Soda Lime	3530 mg
Sodium Arsenite	41 mg
Sodium Azide	27 mg
Sodium Bisulfite	2000 mg
Sodium Borate	2660 mg
Sodium Bromate	300 mg
Sodium Bromide	3500 mg
Sodium Carbonate	4090 mg
Sodium Chlorate	1200 mg
Sodium Chloride	3000 mg
Sodium Chromate	52 mg
Sodium Cyanide	6.4 mg
Sodium Dichromate	52 mg
Sodium Fluoride	52 mg
Sodium Iodide	4340 mg
Sodium Nitrate	3236 mg
Sodium Nitrite	85 mg
Sodium Perborate	1200 mg
Sodium Phosphate, Tribasic	6500 mg
Sodium Salicylate	1200 mg
Sodium Silicate, meta	1153 mg
Sodium Sulfite	820 mg
Sodium Thiocyanate	764 mg
Stannous Chloride	700 mg
Strontium Nitrate	2750 mg
Styrene	5000 mg
Succinic Acid	2260 mg
Sulfamic Acid	3160 mg
Sulfanilamide	3900 mg
5-Sulfosalicylic Acid	2450 mg

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

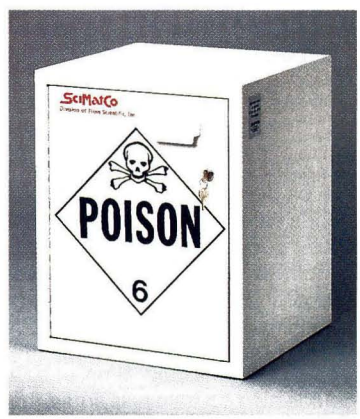
Tannic Acid	2260 mg
Tetrahydrofuran	2500 mg
Thioacetamide	301 mg
Thiourea	125 mg
Thymol	980 mg
Toluene	636 mg
Trichloroacetic Acid	400 mg
1,1,1 Trichloroethane	10300 mg
Trichloroethylene	2402 mg
1,1,2 Trichloro Trifluoroethane	43000 mg
Triethanolamine	8680 mg
Tris-(Hydroxymethyl) Aminomethane	5900 mg
Uranyl Nitrate	12 mg
Urethane	1800 mg
Xylenes	4300 mg
Zinc Acetate	794 mg
Zinc Chloride	350 mg
Zinc Nitrate	1190 mg
Zinc Oxide	630 mg
Zinc Sulfate	2150 mg

Safer Storage

Provide an extra safety edge for the storage of severe poisons. Chemicals that have an LD_{50} of less than 250 mg should be stored in a separate and secure storage cabinet to protect against theft, vandalism, or fire.

The Flinn/SciMatCo Poison Cabinet is compact; it fits into an existing storage cabinet or shelf.

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



Catalog No.	Description	Price/Each
SE6080	Flinn/SciMatCo Wooden Poison Cabinet	$324.00

See page 876 for more information.

Flammable Liquid Safety

Safety Tips for Using Flammable Liquids in School Laboratories

Introduction

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

Safety Precautions

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

Purchase

- Before purchasing any organic liquids, ask the following questions:
  - — Do I understand the hazards of this material?
  - — How often is this chemical used in school setting?
  - — What is the educational value of this chemical?
  - — Have I used this chemical before?
  - — Is my lab equipped for the safe use and storage of this chemical?
  - — If these questions cannot be answered positively, please reconsider purchasing the chemical.
- Organic compounds are not easy to dispose of and frequently require costly disposal methods. Purchase only what is required for 1–2 years' usage.
- Purchase smaller-sized bottles of flammable liquids whenever possible to keep them fresh and to make storage and handling easier. It is easier to handle a 100- or 500-mL bottle than a 1- or 4-liter jug of liquid. Smaller bottles of liquids also contain less liquid that is likely to spill during an accident and thus add less fuel to a potential fire.
- Always purchase flammable liquids in plastic bottles or in PVC-coated glass bottles. PVC-coated bottles will not shatter and spill material when dropped.

Storage

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

Store all flammable liquids in a dedicated flammables cabinet.

- The chemical storeroom should also be equipped with a small, corrosive-resistant exhaust system. Flinn Scientific recommends a fan that will provide four air changes per hour. The fan should be placed near the ceiling of the storeroom. Since organic vapors are heavier than air, the exhaust system must draw vapors from the floor. Use a galvanized sheet metal duct to draw air from the floor to the exhaust fan near the ceiling. (See page 919.)
- If a flammables cabinet in not available, store the flammable liquids in a Flinn *Saf-Stor*® can. This will provide good secondary containment and protection during fires.
- Never store flammable or combustible materials near strong oxidizing agents. As these materials react with one another, heat is evolved and a fire can occur. Use the Flinn Scientific Chemical Storage Pattern to prevent storage accidents. (See pages 962–969.)
- Never store flammable liquids in a household refrigerator or freezer. Vapors can build up inside the refrigerator and a spark from the compressor, thermostat, lightbulb, or electrical switch can ignite the vapors. Explosion-proof refrigerators can be purchased but cost 3–4 times more than household refrigerators.
- Diethyl ether may form explosive peroxides over the course of 1–2 years. Buy and store only small quantities of this material.
- Some alcohols form peroxides upon standing. These peroxides can be explosive if they are allowed to accumulate or are concentrated. Do not distill these materials. Consult the *Flinn Scientific Catalog/Reference Manual* or MSDS to determine storage recommendations for specific alcohols.

Transporting

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

Using and Dispensing Flammable Liquids

- If volatile organic solvents are going to be used, the lab must be well ventilated or have a working purge fan to ventilate the lab. The laboratory should also be equipped with one or two ABC,

FLAMMABLE LIQUID SAFETY continued on next page.

FLAMMABLE LIQUID SAFETY, continued

dry chemical fire extinguishers and fire blankets in addition to the other normal safety equipment (safety eyewash, safety shower, etc.).

- Always review the MSDS before using any hazardous material in the laboratory.
- Flammable liquids should not be mixed with strong oxidizing agents. As the organic material is oxidized, heat is evolved and may ignite the material resulting in a fire.
- Extreme care must be taken when using flammable liquids around any heat source, flames, or electrical equipment. Laboratory equipment (stirrers, meters, etc.) are designed to be sparkproof, but limiting vapors is a good safety precaution.
- Organic vapors are heavier than air and will quickly travel along a lab bench or floor to an ignition source. Never use flammable liquids around an ignition source. Try to minimize the amount of volatile liquids used and be aware that organic vapors can travel great distances.
- Flammable liquids are very volatile. Dispense them in an operating fume hood.
- Use lab mats and/or plastic trays when dispensing organic solvents to contain spills and drips.
- Students should dispense flammable liquids from smaller bottles to limit spills and fumes. Do not allow students to dispense flammable liquids from a 4-L jug. The larger quantity increases the possibility of contamination and increases the amount of fuel in case of a fire.
- During lab, dispense the flammable liquid from a central dispensing location and have students bring a graduated cylinder or test tube to the dispensing area. This will help to minimize spills and accidents as well as limit the amount of flammable liquid being transported back to the lab bench.

Dispense flammable liquids in an operating fume hood

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

Personal Protection Equipment and Safety Aids

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

First Aid

- Always seek professional medical attention upon exposure to any hazardous chemical, especially volatile organic solvents. For most organic solvents, the major hazards are flammability and inhalation. If there is a spill or accident, immediately remove any flames, heat, or electrical equipment from the area and begin to ventilate the area.
- If an organic liquid is splashed in the eyes, use an eyewash to irrigate the eyes with fresh, potable water for at least 15 minutes. Make sure the eyelids are held open to properly irrigate them. Ask the victim to look up, down, and sideways to better reach all parts of the eye. After using eyewash, always seek professional medical help immediately.
- If a flammable liquid is splashed onto bare skin, rinse the area with water for at least 15 minutes. Many organic solvents will "dry out" the skin and cause minor dermatitis. If the liquid causes burns or other skin irritations, seek medical help immediately.

Always consult the MSDS for safety precautions.

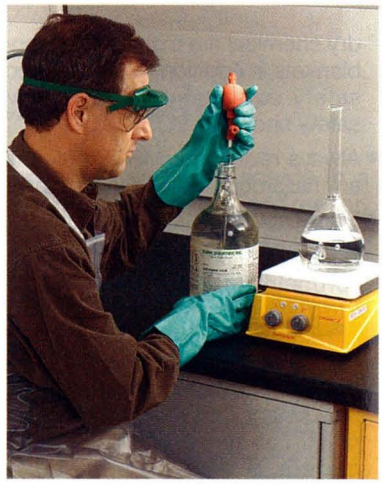
- If a large amount of flammable liquid is splashed onto clothing, consider removing the clothing immediately and placing the clothing in a fume hood or outdoors. If flammable liquid splashes onto your skin and clothing, remove clothing and then begin rinsing the affected areas with water (safety shower is ideal).
- If an organic liquid is ingested, please consult the MSDS and immediately call a poison control center or local hospital emergency room. Follow their directions and seek medical attention as soon as possible. For most organic solvents, the goal is to trap the chemical in the stomach and prevent further injury caused by vomiting. Activated charcoal is sometimes given to help trap the chemical. Do not give the victim anything to drink or induce vomiting unless instructed by a medical professional.

Disposal

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

Acid Safety

Safety Tips for Using Acids in School Laboratories



Introduction

The use of acids is an important component of most chemical laboratories. Understanding the properties and hazards of acids are important initial steps to safe purchase, storage, use, and disposal of acids.

Safety Precautions

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

Purchase

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

Storage

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

ACID SAFETY continued on next page.

Properties

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

ACID SAFETY, continued

probably been contaminated with an organic material and its purity should be in question.

- Concentrated phosphoric acid has a melting point close to ambient temperature and may also crystallize in a cool storeroom. Phosphoric acid is hygroscopic and will absorb water over time. Keep tightly sealed.

Transporting

- Secondary containment is critical to prevent major spills or accidents when transporting acids. Use PVC-coated acid bottles or unbreakable bottle carriers.
- A good habit is to check the acid bottle for cracks before touching or picking it up. Also check for spilled acid on the handle or bottle.
- Always carry 2.5-L acid bottles with one hand underneath the bottle and the other hand around the neck or finger hole. This keeps the bottle closer to your body and decreases the risk of hitting a sharp object, like a desk corner, and breaking the bottle.
- Plastic or rubber safety bottle carriers should be used whenever acids are transported from one laboratory to another or from the storeroom to a laboratory.
- If a cart is used to transport hazardous chemicals, such as acids, place compatible chemicals inside an unbreakable secondary containment vessel, such as a plastic tote. The cart should be equipped with guardrails to prevent plastic totes or bottles from sliding off the cart.
- If hazardous chemicals are moved from one floor to another, use an elevator if possible. Only the teacher transporting the chemicals should be on the elevator. Although elevator accidents are rare, should a dangerous material be released in an elevator while passengers are trapped inside, the results could be catastrophic.

Preparation of Acid Solutions

See Chemical Solution section, p 953.

To Prepare a Solution

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

Always add acid to water...

Using and Dispensing Acids

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

Personal Protection Equipment and Safety Aids

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

First Aid

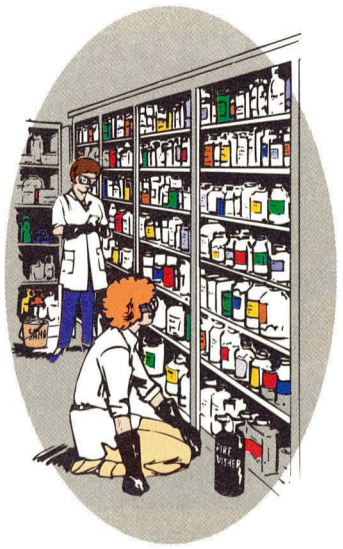
- Always seek professional medical attention upon exposure to any hazardous chemical, especially concentrated acids.
- The best first aid for any chemical exposure to body tissue or eyes is immediate dilution with water.
- If an acid is splashed in the eyes, use an eyewash to irrigate the eyes for at least 15–20 minutes. Make sure the eyelids are held open to properly irrigate them. Ask the victim to look up, down, and sideways to better reach all parts of the eye.
- If an acid is splashed onto bare skin, rinse with water for at least 15–20 minutes.
- If an acid is splashed onto clothing, consider removing the clothing immediately before the acid soaks through the clothing and reacts with the skin. If an acid splashes onto your skin and clothing, immediately begin rinsing the affected skin with water (safety shower is ideal) and then begin to remove affected clothing. Modesty must take a back seat to the potential chemical burns that can occur.
- If acid is ingested, the primary goal is to dilute the acid in the stomach and prevent further injury caused by vomiting. If the victim is conscious, immediately have the victim rinse their mouth out with water. Have the victim drink one or two cups of water or milk. Gastric antacids such as milk of magnesia or aluminum hydroxide can also be given. Do not induce vomiting, do not try to neutralize the acid with a strong base, and do not give the victim any sodium bicarbonate or any carbonated drinks. Call a poison control center or hospital emergency room and follow their directions.

Always dilute and neutralize acids before disposal.

Disposal

- Always dilute and neutralize all acids before disposal.
- See Flinn suggested laboratory chemical disposal procedures #24a and #24b in a current *Flinn Scientific Catalog/Reference Manual* for detailed disposal procedures and warnings.

Seven-Step Plan to Clean Up Your Chemical Storage Area



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

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

- Teachers cleaning up the chemical storage area should do so in teams. This work should never be done alone. Students should never be involved.
- Teachers doing this work should be from the school where the work is being done. The best time to do this type of work is immediately after school gets out in the spring.
- Teachers should be hired on an extended contract during the summer months to undertake this project. For an average-sized school of 1000 students, it will take a team of three to four teachers two weeks to clean up the chemical storage area.
- Teachers on an extended contract should also be covered by the school's insurance policy in the unlikely event of an injury.

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

STEP 1: Take an Inventory

The most important step in cleaning up a chemical storage area is taking an accurate and complete inventory of every chemical in every chemical storage area, laboratory and classroom. Without a complete inventory you will not be able to proceed to step #2. Don't forget to check closets and drawers. Details on how to take an inventory can be found on pages 962–966 of this *Flinn Scientific Catalog/Reference Manual.* Please read these instructions carefully!

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

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

STEP 2: What Chemicals Do You Really Use?

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

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

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

STEP 3: Organizing Your Chemical Storage Area

You now know which chemicals you use, which chemicals you want to keep, and which chemicals you would like to get rid of. Let's now physically move all of the chemicals in the chemical storage area (and anywhere else you found chemicals) out into the laboratory area and onto the lab benches. (The laboratory next to the chemical storage area works best.) The right side of the laboratory will become an area for those chemicals which you either no longer use, or have excessive amounts of and would like to dispose of.

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

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

There are certain chemicals found on school premises which Flinn Scientific considers to be "devils." A "devil" is any chemical which has a severe hazard alert. Severely poisonous, severely toxic, severely flammable, severely corrosive, strong oxidizer, carcinogen or strong stench are all characteristics which may qualify a chemical as a "devil." Our list of "devils" can be found on page 302 of this Catalog/Reference Manual.

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

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

Once the chemical bottle is in the Baggie, spread a thin layer of cat litter in the bottom of a paint can, place the sealed Baggie with the chemical container into the paint can and fill the remaining portion of the can with cat litter. Place the lid on the paint can and label the can clearly with the chemical name, chemical formula, and hazard risk. Your "devil" chemical is now well protected!

SEVEN-STEP PLAN continued on next page.

SEVEN-STEP PLAN TO CLEAN UP YOUR CHEMICAL STORAGE AREA, continued

The metal paint can may be dropped, kicked, or even involved in a fire and the chemical container inside will not break. Should a leak occur, the cat litter will absorb the chemical and the spill will be contained inside the can.

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

STEP 5: Improve the Chemical Storage Area Facility

Now that the chemicals have been moved out of the chemical storage area and into the laboratory, you have an opportunity to make some improvements to the chemical storage area. First of all, give the room a good cleaning. Make sure the shelves are firmly attached to the wall and are in good condition. If the shelves are not in good condition, some type of repair or replacement should be made. Check the shelf clips carefully to make sure they are in good condition and not corroded. Better yet, replace the "adjustable" shelves with permanent shelves that will never collapse. Put "lips" on the shelves to prevent bottle roll-off. (If you want to learn more about shelf lips, see the "How to" box on page 913.) Inspect the rest of the chemical storage area. Do any other improvements need to be made?

STEP 6: Organize Chemicals by Compatible Families

Now that the "devil" chemicals have been bagged and canned, and the storage area has been improved, it's time to return the chemicals you want to keep back into the chemical storage area. Before these chemicals are moved back into the chemical storage area, you must decide how they are to be stored and organized. In the past, they may have been stored alphabetically. This is wrong! Chemicals should be stored and organized by compatible chemical families. Pages 966–969 of this *Flinn Scientific Catalog/Reference Manual* describe how to properly store laboratory chemicals. Thousands of schools across the United States have adopted the Flinn Suggested Chemical Storage Patterns for the storage of their laboratory chemicals. Many states and insurance companies recommend the Flinn Suggested Chemical Storage Patterns as the preferred method of chemical storage.

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

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

STEP 7: Chemical Disposal—Your Options

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

As you walk out of the chemical storage area feeling good about what you have accomplished, you soon realize you still have all of those chemicals that need to be disposed of. What are your options for chemical disposal? Flinn has devoted 33 pages in this Catalog/Reference Manual to disposal procedures. First read about your options on page 973 and if you want to dispose of small quantities of chemicals, refer to the disposal procedures found on pages 975–1005.

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

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

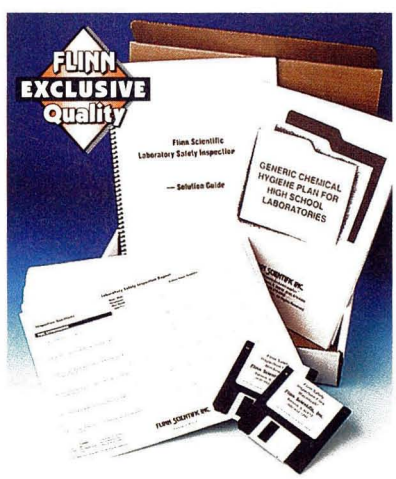
Laboratory Safety Inspection Kit

Are your science laboratories safe? Conduct a safety inspection! The Flinn Laboratory Safety Inspection Kit will identify existing and potential safety problems, provide the correct procedure or policy to solve the problem, and document the safety problems in writing to your school's administration.

The Flinn Laboratory Safety Inspection Kit consists of three key ingredients:

- *Safety inspection worksheets.* Use these reproducible forms to conduct your safety inspection.
- *Safety solution booklet.* For every question asked during the inspection, the correct policy or procedure to fix the problem is provided.
- *Safety inspection report.* A standard safety inspection report is provided as a Microsoft Word® file. The report is easily edited to meet your specific needs and will save you hours of time. Once the report is completed, you may submit your detailed report to your school's administration for further action.

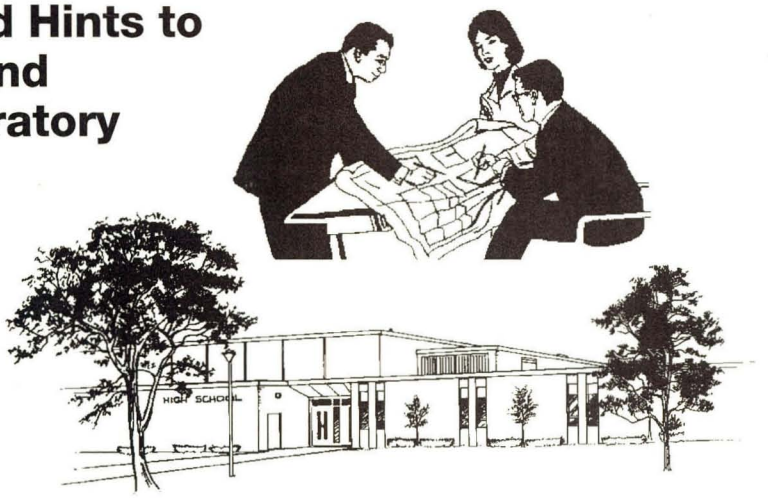
The Flinn Laboratory Safety Inspection Kit will not only help to identify existing and potential safety problems, but also help you to properly document the problems to present to your administration.



Catalog No.	Description	Price/Each
AP4851	Laboratory Safety Inspection Kit	$39.95

Chemistry Laboratory Design

Forty-five Ideas, Tips, and Hints to Help You Design a Safe and Efficient Chemistry Laboratory



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

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

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

Chemistry Laboratory:

1. Will the laboratory have a fume hood? Will the fume hood have gas, electricity, water, and a sink? Where will the fume hood be located in the laboratory? A good rule of thumb is to keep the fume hood location away from heavy student traffic areas and main exits.
2. Table tops should be black epoxy resin.
3. Floors should be vinyl tile. Properly installed they are easily cleaned and relatively chemical resistant. Consider using non-skid wax. Carpet should never be used in a chemistry laboratory!
4. A handicap access lab station should be provided in at least one chemistry lab.
5. Ventilation in the chemistry lab is a must. Each laboratory must have its own ventilation purge fan which removes at least 3200 cubic feet of air per minute. These fans should be vented directly to the out-of-doors and should not be interconnected between rooms. An on/off switch should be provided allowing the instructor to turn the fans on and off depending on the types of labs being conducted. The fans are not intended to be run all day long, but on an as-needed basis.

   Your ultimate goal with a purge fan is to have a complete room air change in five minutes. Positioning of the fan will depend on your laboratory design. Remember fume hoods are not designed for general lab ventilation!
6. Make sure you have plenty of electrical outlets with ground fault interruption.
7. Will computer cables be run to each lab station for future use of computers?
8. Knowing that these labs are being designed to last 30 or more years, should the lab be designed to include some common features so biology and physics may be taught there?
9. A fire blanket, fire extinguisher (ABC type), eyewash, and a shower or body drench (with drain) should be placed in each chemistry lab. Depending on where the teacher's demonstration table is located in relationship to the general lab area, you may need two eyewashes, fire blankets and fire extinguishers.
10. Will you have a demonstration table? Will it have water, electricity, gas and a sink? A large sink is always nice to have in a demonstration table.
11. Master utility cut-off valves for gas and electricity are essential. Make sure they can be accessed easily in case of emergency.
12. Where will goggles be stored? Where will students hang or store their aprons?
13. Look at furniture designs which maximize student spacing at each lab station. A good reference on class size is an article written by Flinn Scientific entitled "Overcrowding in the Science Laboratory". A copy of this article can be found in your current edition of the *Flinn Scientific Catalog/Reference Manual*. See pages 944–945.
14. Good sight lines are critical for a chemistry teacher. Can you see most of the lab activity from one vantage point? Can you move easily from one lab station to another without going around student desks and chairs? Your ability to supervise students' lab activity must not be compromised.
15. Do you have ample storage for apparatus, hardware, equipment, etc.?
16. Are sinks a usable size? Do you want hot and cold water at each lab station?
17. All safety equipment must be marked with location placards/signs.
18. Do you need non-reactive waste receptacles? Fireproof trash cans?

CHEMISTRY LABORATORY DESIGN continued on next page.

CHEMISTRY LABORATORY DESIGN, continued

19. Where will spill control materials be stored in the chemistry lab?
20. Do you want laboratory stools? It is our position that stools should not be used when students are in the lab.
21. Do you want dry erase or chalkboards in the lab? Where do you want them located?
22. Does your state require two exits? If so, where will they be located?
23. Will the laboratory have ample lighting? 75 to 100 foot-candles is suggested at bench level.
24. Do exit doors have sturdy locks and self-closing return hardware?
25. Contact the four major laboratory furniture companies listed below. They are all fine companies and will provide free assistance in designing your labs. Their catalogs are valuable resources and provide lots of ideas. Make good use of these free resources.

Preparation/Chemical Storage Area:

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

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

Contact the five major laboratory furniture companies discussed in this article. Their resources and ideas are invaluable.

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

Laboratory Furniture Companies You Should Contact When Designing a Chemistry Laboratory

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

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

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

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

Mohon International, Inc.
P.O. Box 550, Paris, TN 38242 • (901) 642-4251 • www.mohon.com

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

Chemical Safety in the Lab

Chemical Purchasing Suggestions Guaranteed to Make Your Lab a Safer Place to Work and Teach

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

Chemical Labeling

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

- Chemical Name, Grade, Purity, and Concentration
- Hazard Alert
- A Chemical Safety Guide telling the user what safety aids should be available before the chemical is used.
- Warning Information
- First Aid Procedures
- Lot Number
- Compatible Chemical Storage Family
- Suggested Disposal Method
- Shelf Life
- Solubility
- Date Purchased
- C.A.S. Number
- NFPA Code

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

No Need to Repackage



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

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

Chemical Packaging

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

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

The type of container in which a hazardous chemical is packaged may determine whether or not you purchase the chemical in the first place. For instance, most chemical suppliers package magnesium ribbon in a wax paper bag. Flinn Scientific packages magnesium metal ribbon in an air-tight zipper-lock bag to prevent the magnesium ribbon from oxidizing.

The packaging of 30% hydrogen peroxide is another good example. Flinn Scientific packages 30% hydrogen peroxide in an exclusive "accordion" bottle. This unique container expands as oxygen is released—eliminating the possibility of the teacher opening the bottle under pressure.

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

Chemical Package Sizes

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

The shelf life of your chemicals is an important concern. Some chemicals become more hazardous with age. Purchasing in small quantities will allow you to have new, "fresh" chemicals on the shelf at all times. One labeling specification is that the purchase date appear on the chemical label. Having this information available will help you know how old your chemicals are and if a shelf life problem exists.

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

Flinn Scientific has over 500 chemicals available in small package sizes.

Conclusion

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

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

Special 30% Hydrogen Peroxide Bottle



Flinn's special accordion H_2O_2 bottle expands as oxygen is released. This unique "safety bottle" keeps the hydrogen peroxide in the bottle and prevents the possibility of opening the bottle under pressure. Depend on Flinn for "state of the art" chemical packaging.

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

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

Goggle Safety

What Do the ANSI Standards Really Mean?

An important obligation of a responsible science teacher is to provide students with safe, appropriate eye protection. As you compare the wide array of goggles and safety glasses, you often see the phrase "Meets ANSI Z87.1 Standards". In the *Flinn Scientific Catalog/Reference Manual* we list several eyewear styles which all meet the ANSI standard. Obviously, there must be more to choosing safe eyewear than merely picking any style which meets this standard. To choose the most suitable eyewear for yourself and your students it is helpful to understand ANSI and its relationship to regulations concerning school laboratories.

What Is ANSI Z87.1?

The American National Standards Institute (ANSI) is a non-profit association which publishes standards covering a broad range of equipment and industries. The complete title of the current ANSI document pertaining to eyewear is *American National Standard Practice for Occupational and Face Protection*, ANSI Z87.1—1989. This document includes standards for several different styles of safety eyewear ranging from eyeglass-type spectacles to heavy-duty welding helmets. Each style has its own standards.

ANSI's objective is to provide basic performance requirements for eye and face protection.

For example, the tests listed below are two of the standards for removable goggle lenses:

- Lenses shall resist impact from a 25.4 mm diameter steel ball dropped from 127 cm.
- Lenses shall resist penetration from a projectile weighing 44.2 g dropped from 127 cm.

For clarification of the relevance of these standards to your choice of laboratory eyewear it is helpful to understand more about ANSI and Z87.1.

- ANSI is not a federal agency. As an independent association it is not involved in establishing or enforcing the OSHA Laboratory Standard.
- ANSI does not test, inspect or approve eyewear. The eye protection manufacturer can choose to contract an independent testing facility to conduct tests to determine if their products meet ANSI standards.
- There are important factors that are difficult to measure and are not covered in Z87.1 that must be considered when choosing eyewear. Among these are durability, comfort, anti-fog performance and chemical splash protection.

Keep in mind that not all eyewear is created equally. There are a lot of cheaply-made goggles on the market that will not survive even one semester. How safe is a goggle if it meets ANSI standards, but it is left in a desk drawer, unworn, because it is broken or uncomfortable?

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

Chemical Splash Protection

Just because eyewear meets Z87.1 standards does not necessarily mean it provides adequate protection from the dangers of splashed chemicals. Eyewear that does not provide a complete, snug seal around the eyes may be fine for some activities but not when using hazardous chemicals. When vent openings are provided on splash goggles the vents should be indirect, with covers and/or baffles preventing straight-line passage of liquids into the goggle.

The Choice Is Up To You

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

ANSI Z87.1 Section 7.3(3) page 15

The teacher must "make a judgement in selection of the appropriate protective equipment so that the protection is greater than the estimated hazards".

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

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



Flinn's most popular chemical splash goggle offers comfort and coverage.

Basic Recommendations

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

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

Conclusion

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

Steps You Can Take to Prove You're a "Responsible" Science Teacher

Student X had a bad accident involving a chemical he obtained at school. As a high school chemistry student, he was able to obtain a sizeable piece of elemental potassium from the stockroom. He wrapped the potassium in a paper towel and placed it inside his front pants pocket. Soon after, he walked home and by the time he was inside his house, the potassium spontaneously ignited and caught his pants on fire. The student sustained third-degree burns to his leg and abdomen that required skin grafting.

All science teachers dread the thought of having this type of "event" occur at their school. Who's responsible? The teacher? Student? School? A good definition for "who is responsible" is: "If you can reasonably foresee the consequences of what you're about to do, or are not about to do, you will be held responsible."

Today's science teachers must not only act responsibly, they must also be prepared to prove to others how they have acted responsibly. Below are a few inexpensive ideas you can use in your classroom to document that you are a responsible science teacher.

Safety Contracts

The first day of school you need to establish a contractual relationship with your students. A student safety contract is a detailed listing of all of the rules of the laboratory. Review the safety contract with your students and have them sign and date it. Students should then take the contract home so their parents or guardians can review and sign the contract as well. As a responsible science teacher, you think safety is so important that you want the parents to be involved the very first day of school. If the student, or parent, does not sign the contract, the student will not be allowed to participate in any laboratory activity and will be given a failing grade for each day missed.

Does the safety contract have any legal weight? No, it does not. However, it does tell the students and parents that you are very serious about safety. Signed safety contracts will also go a long way in establishing that you are a responsible science teacher. Signed safety contracts document that the rules of the laboratory have been reviewed by all of the students in your class and you have their signatures to prove it.

If you don't wish to prepare your own safety contract, Flinn Scientific has developed a safety contract based on teachers' input. To request a free sample of the Flinn Safety Contract, please write to:

Flinn Safety Contract
P.O. Box 219
Batavia, IL 60510

Flinn Safety Contract is also available in pads of 50 contracts (AP4236) for $4.75 (see page 907).

Lesson Plans

Your lesson plan book is a very valuable document to have should you ever have to prove to someone that you are a responsible science teacher. Your lesson plan book is your personal journal or diary which documents all of the activities you have done in class for the entire school year. Your lesson plan book is also a great place to document all the safety discussions you have with your students.

Every time you discuss safety in class, jot down in your lesson plan book what you talked about. For instance, the day you discuss the safety contract, your lesson plan book should note that the safety contract was reviewed and discussed. Every time a lab or demonstration is done, select one of the rules from the safety contract, remind the students of the rule, and make note in your lesson plan book accordingly. Responsible science teachers constantly reinforce safety rules every day and get in the habit of writing in their lesson plan book what was discussed.

Safety Posters

Most students are visual learners. Bright, colorful safety posters throughout the classroom/laboratory will help remind students that safety is important. While Flinn Scientific would love for you to order our Safety Posters, we urge you to have students make their own. The next time you are absent from school and a substitute teacher watches the class, make that day a "safety day"! Provide the students with crayons, poster board, paper, and markers and have them make safety posters based on the safety contract. Decorate the walls with their homemade posters. Of course, your lesson plan book will clearly show that you think science safety is so important that your students spent the entire day making safety posters. What would normally have been a video day or worksheet day has now become an important safety day!

Firm Goggle Policy

A responsible science teacher must adopt a firm goggle policy. The policy we hope your school will adopt is "Any time chemicals, glassware, or heat is used, you must wear your laboratory goggles. No exceptions!"

Chemical Terms

When discussing laboratory safety the first couple weeks of school, you will be using terms like corrosive, flammable, oxidizer, etc. Do your students understand the meaning of these terms? I suspect not! Try to explain and demonstrate to the students what these terms mean. We have a wonderful demonstration to illustrate the concept of corrosion using egg whites. If you would like a copy of this demonstration, please write to:

Flinn Scientific, Inc.
P.O. Box 219
Batavia, IL 60510

Safety Tickets

If a student violates a rule in your laboratory, shouldn't that student be given a ticket? The safety ticket can be prepared on two-part carbonless paper. Have a space for the student's name, date, class period, a checklist of the three most common rule violations, a space for you to write in the violation if it has not been previously listed, and spaces where the student and teacher can sign the ticket. Every time a lab rule is broken, the student will write himself a ticket. The student gets a copy and you get a copy.

Three tickets and the student will be required to take a safety test based on...you guessed it, the safety contract. Five tickets and the student gets detention. Seven tickets and the parents are called and you make every effort to kick the student out of class. Anyone who has seven tickets is not only a safety risk to themselves but to every person in that laboratory.

If you don't wish to prepare your own safety tickets or safety test, please refer to pages 906–907 for a whole line of liability reduction products.

Conclusion

"If you can reasonably foresee the consequences of what you are about to do, or are not about to do, you will be held responsible." Begin to implement some of the ideas we have suggested. Safety contracts, lesson plans, safety posters, a firm goggle policy, definition of terms, and safety tickets will all go a long way in helping to prove you are a responsible science teacher.

Practical Solutions to Reduce Your Liability

Introduction

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

11. *Be proactive rather than reactive.*

Acknowledgment

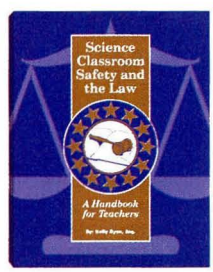
Kelly Ryan was a science teacher in San Gabriel High School in California for 15 years and is now a practicing attorney. He has written a book entitled *Science Classroom Safety and the Law—A Handbook for Teachers* (see below).

Science Classroom Safety and the Law—A Handbook for Teachers

By: Kelly Ryan, Esq., Attorney at Law

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

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



Catalog No.	Description	Price/Each
AP6118	Science Classroom Safety and the Law	$20.95



Overcrowding in the Science Laboratory

What is the maximum number of students you should have in your science laboratory? How much lab space should be available for each science student?

These are two of the most frequently asked questions we receive each year. The frequency of these questions points out the safety consciousness of today's science teacher. This article is intended to provide you with guidelines on how to help solve the problem of overcrowding in the science laboratory. We hope you and your administration will evaluate and adopt these guidelines in an effort to provide a safer working and improved learning environment for teachers and students.

Many school districts are experiencing budget problems. Any and all solutions to reduce school spending are being considered. One of the many solutions school administrators are considering to help "ease" budget problems is to increase the number of students in each class. Increasing class size not only delays the need to hire additional teaching staff, but also postpones the need to provide additional classroom space. For the science laboratory this solution creates major problems.

Overcrowding increases safety problems.

Health and Safety Concerns

Science teachers sense that overcrowded conditions in their science laboratories contribute to lab accidents. Their safety sense has not failed them! Overcrowding in the science laboratory is a major contributing factor to the safety problems school science departments face today.

In 1988, a report published in the *Florida Science Teachers Magazine*, Spring Edition, 1988, by Phillip Horton entitled "Class Size and Lab Safety in Florida" documented that over 55% of the science classes had enrollments teachers considered to be "potentially unsafe" for lab work. The average class size in these "unsafe" classrooms was 31 students. Of the 45% of the science classrooms teachers considered to be "safe," the average class size was 23 students. One high school teacher surveyed had two classes where the number of students was within the designed enrollment capacity, and three classes where enrollments exceeded the room capacity. He said "Contrasting the number of accidents between the first two periods and the last three...class size does make a significant difference in traffic flow, individual monitoring, and understanding of the students!" The facts are clear, increasing the number of students in a science laboratory increases the likelihood of accidents. A high pupil/teacher ratio constitutes a threat to laboratory safety.

While we are concerned about the safety of the students, let's not forget that overcrowded conditions in the science laboratory also present an unsafe working environment for the science teacher as an employee of the school district. Most science laboratories are designed to accommodate 24 students, an accepted professional standard. When class sizes are larger than 24 students, it becomes very difficult for the science teacher to safely handle, transport and use laboratory chemicals and equipment. Increased class size puts "at risk" the health and safety of the science teacher.

Academic Concerns

Though student safety in the science laboratory is a major reason for limiting class size, another consideration is the ability to provide quality laboratory instruction. Many laboratory experiences require a high degree of student–teacher interaction. The fewer students there are in a laboratory, the greater the opportunity for students to ask questions and for teachers to clarify procedures and encourage the development of reasoning skills.

The amount of personal instruction provided each student must be considered. As one teacher who was teaching in an overcrowded science laboratory put it, "There is simply not enough teacher to go around and give sufficient time to each student."

Science teachers report that their classes are being held in rooms that were never designed for the teaching of science. Other teachers have had to discontinue the number of hands-on labs they do each year because they now have less preparation and set-up time.

Overcrowding also increases discipline problems. In a lab situation, discipline problems will result in "unsafe" conditions.

Overcrowding increases discipline problems.

Class sizes in some schools have grown so large that teachers no longer run hands-on labs because of unsafe conditions caused by overcrowding. Apparently some teachers have concluded that the risks involved in conducting labs in overcrowded laboratories are greater than the benefits the lab experiences provide. How many science laboratories are considered "safe" because the lab work has been removed from the curriculum? Is this the direction we want science education to go? We think not!

The Professional Standard

When discussing the issue of overcrowding, teachers and administrators should evaluate not only class size, but also the amount of space provided each student in the science laboratory.

The National Fire Protection Association (NFPA) has stated that "50 sq. ft. net area occupant load factor is appropriate for use in science laboratories in middle and high schools." For a class size of 24, this would be a 1200 sq. ft. laboratory.

The California Administrative Code [Title 2 Subchapter 4, Section 1811 (g)] requires that school design provide 1300 square feet for 24 students. This figure includes preparation areas as well as apparatus and chemical storage space.

The state of Vermont's revised standards for approving Vermont's public schools (Section 2160.4, Page 15; adopted January 2, 1991) states "No science laboratory class enrollment shall exceed the capacity of the available lab stations." This revised standard further states (Section 2191, Page 36, adopted January 2, 1991) that "classrooms are free of overcrowding and suited to the teaching strategies employed."

OVERCROWDING continued on next page.

OVERCROWDING IN THE SCIENCE LABORATORY, continued

Vermont's School Buildings And Sites—Approval of Projects For State Aid Purposes (6200) states under the heading of floor area for the science laboratory (6241.1) that "50 square feet/student" be provided.

In Texas, the Texas Education Agency (TEA) has published *Planning a Safe and Effective Science Learning Environment*. On page 14 under High School Science Facilities it states: "Science classes should be limited to a maximum of 24 students in any one class provided adequate laboratory space exists for this number. It should be noted that 24 is not an average enrollment but a maximum in any one class." This publication was developed to aid Texas school administrators, teachers and architects to meet the instructional requirements of Title 19, Chapter 75 of the Texas Administrative Code.

The State of Georgia IEC Code #160-5-1-.08 entitled Class Size states: "The purpose of this rule is to establish maximum class sizes and guidelines for the computation of class size and system average class size." The ruling goes on to say that science labs should not exceed a "maximum system average class size of 24.2 students or a maximum individual class size of 28."

NSTA states: Lab classes should not exceed 24 students.

In the book *Pathways to the Science Standards—High School Edition*[1] it states: "Space is an important factor in promoting inquiry, collaborative learning, and safety. Considering current technology needs and teaching practices, a good science room will require a minimum of 60 ft.^{2} per pupil (5.6 m^2), which is equivalent to 1,440 ft.^{2} (134 m^2) to accommodate a class of 24 safely in a combination laboratory/classroom—*or*—a minimum of 45 ft.^{2} per pupil (4.2 m^2), which is equivalent to 1,080 ft.^{2} (101 m^2) to accommodate a class of 24 safely in a stand-alone laboratory. In addition, 10 ft.^{2} (0.9 m^2) per student is needed for teacher preparation space and for separate storage space (240 ft.^{2} or 22 m^2, for a class of 24)."

It is important to note that *Pathways to the Science Standards—High School Edition* is a guidebook which provides step-by-step guidance on what the National Science Standards mean and how to begin to implement change in the classroom. This is very powerful information you can use in your fight to keep class size down to a reasonable number of students.

In 1986, the National Science Teachers Association (NSTA) and the National Science Supervisors Association (NSSA) adopted a statement entitled "Working conditions for secondary classroom teachers". In paragraph VI it states "Because of safety considerations and the individual attention needed by students in laboratories, science classes should be limited to 24 students unless a team of teachers is available."

In 1990, the National Science Teachers Association (NSTA) adopted a position statement entitled "Laboratory Science." Here they said: "The number of students assigned to each laboratory class should not exceed 24. The student must have immediate access to the teacher in order to provide a safe and effective learning environment."

The above stated positions establish professional standards that are sensible and defensible in that both space per student and class size limit are specified.

A final area of focus is the science teacher as an employee of the school district. The Occupational Safety and Health Administration's (OSHA) 1990 29 CFR Part 1910 requires a safe working environment for employees relative to the use of chemicals in science laboratories. A student/teacher ratio above the professional standards described above creates greater risk of accidents, not only for students, but also for school employees.

The Need for Action

As the science teacher, science department chairperson, or science supervisor of your school district, you are considered to be the "house expert in science." Please do not assume your school administration understands the problems of overcrowding in the science laboratory. It is your responsibility as the "house expert in science" to provide your administration with as much information as you can on this topic. Diplomatically explain to your administration, in writing, why overcrowding in the science laboratory is a problem. Once your school administration is informed of the problem and understands the consequences of overcrowding in the science laboratory, we are sure most schools will try to take some type of corrective action to reduce the number of students in the science laboratory.

If your administration is unable to take corrective action or simply fails to understand the problems of overcrowding in the science laboratory then the school district administration must take full responsibility for their decision. Explain to your school administration, in writing, that you disagree with their decision. Be specific and detail each reason why you are against overcrowding in the science laboratory. Tell the school district that they, not you, will be held responsible for accidents which occur because of their decision to increase your class size. Since they insist on a larger class size, they also need to be aware of the increased liability they have taken upon themselves.

The content of this second letter should be very similar to the earlier letter you sent the school district. This letter should also be sent certified mail—return receipt requested. The signed receipt will provide you with proof that the school district has received your letter.

Administrators must take corrective action to reduce class size.

If you feel these steps are not enough, then we offer one last option which you might want to consider. However, we must strongly warn you that using this option, may get you into some serious "political" hot water.

The option is to involve parents. If parents find out their children's safety is at risk due to overcrowded science laboratories, they will get involved! If parents find out their children are not getting the kind of quality education they deserve because of overcrowded science laboratories, they will get involved! Parents can be very "vocal"! They may be the catalyst you need to have your school district administration solve the problem of overcrowding in the science laboratory.

Remember, the best option of all is to work with your school administration. Together you both can solve the problem of overcrowding in the science laboratory.

Final Thoughts

Overcrowding in the science laboratory is a serious problem. I hope we have provided you with the information you need to argue your case against overcrowding in the science laboratory. If you have other ideas we have not mentioned, please write to us. We will be more than happy to pass your ideas on to our readers in future issues of *Flinn Fax*.

[1] *Pathways to the Science Standards—High School Edition* is published by the National Science Teachers Association. The book is 189 pages, easy to read, and is an absolute must for every secondary science teacher. For your copy order from Flinn Scientific, Inc., Catalog #AP9298, $37.75.

Chemical Spill Control

How to Prevent and Respond to Laboratory Chemical Spills

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

Spill Prevention

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

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

Spill Control Equipment

Proper spill control equipment includes fire blankets, spill control materials such as sand, absorbent, neutralizer, and a mercury spill control kit.

A 100% wool fire blanket is an excellent spill control device because it will contain and control a spill and its vapors. If a spill occurs and no spill control materials are available, simply throw the fire blanket over the spill. The blanket will begin to absorb the liquid, contain the vapors, and will enable a person to walk over the spill without slipping. Remember, acid spilled on a tile floor will become very slippery and the potential for slipping and falling into the acid spill is a real concern.

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

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

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

Spill Control Procedures and Training

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

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

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

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

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

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

Laboratory Solution Preparation

- **Basic concepts of preparing solutions**
- **Over 300 recipes of common laboratory solutions**
- **Solution preparation tips**

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

The section is divided into several parts for your convenience.

- ▶ Basic concepts of preparing solutions
- ▶ Preparation of simple inorganic salt solutions
- ▶ Preparations of acid and base solutions
- ▶ Recipes for Biological, Histological, and Chemical solutions

Basic Concepts of Preparing Solutions

Molarity

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

If starting with a solid, use the following procedure:

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

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

- Example: Prepare 800 mL of 2 M sodium chloride.

  $(MM_{NaCl} = 58.85 \text{ g/mol})$

  $g_{NaCl} = 58.85 \text{ g/mol} \times 2 \text{ mol/L} \times 0.8 \text{ L}$

  $g_{NaCl} = 94.16 \text{ g NaCl}$

  Dissolve 94.16 g of NaCl in about 400 mL of distilled water, then add more water until final volume is 800 mL.

If starting with a solution or liquid reagent:

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

  eq. 2. $M_1V_1 = M_2V_2$

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

  $M_1V_1 = M_2V_2$

  $(12.1 \text{ M})(V_1) = (1.0 \text{ M})(100 \text{ mL})$

  $V_1 = 8.26 \text{ mL conc. HCl}$

  Add 8.26 mL of concentrated HCl to about 50 mL of distilled water, stir, then add water up to 100 mL.

Percent Solutions

Mass percent solutions are determined by the grams of solute per 100 grams of solution.

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

Volume percent solution contains milliliters of solute per 100 mL of solution.

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

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

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

BASIC CONCEPTS OF PREPARING SOLUTIONS continued on next page.

Basic Concepts of Preparing Solutions, continued

Conversion Between Percent Solutions

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

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

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

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

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

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

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

   Density of ethyl alcohol = 0.794 (from handbook)

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

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

2. Mass of solution = 100 g (given)

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

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

3. Volume percent of solution

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

   Reverse the procedure to convert volume percent to mass percent.

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

Calculating Molarity from Percent Solutions

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

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

$$\text{mass} = \text{volume} \times \text{density}$$

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

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

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

Definitions

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

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

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

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

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

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

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

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

Preparation of Simple Inorganic Salt Solutions

Name / Formula / F.W.	Concentration	g/L
Aluminum chloride $AlCl_3 \cdot 6H_2O$ 241.43	0.2 M 0.05 M	48.3 g 12.1 g
Aluminum nitrate $Al(NO_3)_3 \cdot 9H_2O$ 375.13	0.1 M	37.5 g
Aluminum sulfate $Al_2(SO_4)_3 \cdot 18H_2O$ 666.42	0.1 M	66.6 g
Ammonium acetate $NH_4C_2H_3O_2$ 77.08	1.0 M 0.1 M	77.1 g 7.7 g
Ammonium sulfate $(NH_4)_2SO_4$ 132.1	0.1 M	13.2 g
Barium chloride $BaCl_2 \cdot 2H_2O$ 244.28	0.1 M	24.4 g
Barium hydroxide $Ba(OH)_2 \cdot 8H_2O$ 315.50	0.1 M	31.5 g
Barium nitrate $Ba(NO_3)_2$ 261.35	0.5 M 0.1 M	130.7 g 26.1 g
Bismuth nitrate $Bi(NO_3)_3 \cdot 5H_2O$ 485.1	0.1 M	48.5 g in 500 mL 6M HNO_3*
Bismuth trichloride $BiCl_3$ 315.34	0.2 M	63.1 g in 500 mL 3M HCl*
Cadmium chloride $CdCl_2 \cdot 2½H_2O$ 228.34	0.1 M	22.8 g
Cadmium nitrate $Cd(NO_3)_2 \cdot 4H_2O$ 308.49	0.1M	30.8 g
Calcium chloride $CaCl_2 \cdot 2H_2O$ 147.02	1 M 0.1 M	147.0 g 14.7 g
Calcium hydroxide $Ca(OH)_2$ 74.10	saturated	2 g†
Calcium nitrate $Ca(NO_3)_2 \cdot 4H_2O$ 236.16	0.5 M 0.1 M	118.1 g 23.6 g
Chromium (III) chloride $CrCl_3 \cdot 6H_2O$ 266.48	0.1 M	26.6 g
Chromium (III) nitrate $Cr(NO_3)_3 \cdot 9H_2O$ 400.18	0.1 M	40.0 g
Cobalt (II) chloride $CoCl_2 \cdot 6H_2O$ 237.95	0.1 M	23.8 g
Cobalt (II) nitrate $Co(NO_3)_3 \cdot 6H_2O$ 291.05	0.1 M	29.1 g
Cupric chloride $CuCl_2 \cdot 2H_2O$ 170.49	0.1 M 0.5 M	17.0 g 85.2 g
Cupric nitrate $Cu(NO_3)_2 \cdot 3H_2O$ 241.6	0.1 M 0.5 M	24.2 g 120.8 g
Cupric sulfate $CuSO_4 \cdot 5H_2O$ 249.69	1 M	249.7 g
Ferric chloride $FeCl_3 \cdot 6H_2O$ 270.32	0.1 M	27.0 g
Ferric nitrate $Fe(NO_3)_3 \cdot 9H_2O$ 404.00	0.1 M	40.4 g
Ferrous sulfate $FeSO_4 \cdot 7H_2O$ 278.03	0.01 M	2.8 g and 1 mL conc. H_2SO_4*
Lead acetate $Pb(C_2H_3O_2)_2 \cdot 3H_2O$ 379.34	0.1 M	38.0 g

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

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

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

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

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

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

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

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

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

continued on next page.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Lead chloride $PbCl_2$ 278.12	saturated	12.0 g†
Lead (II) nitrate $Pb(NO_3)_2$ 331.2	1 M 0.5 M 0.1 M	331.2 g§ 165.6 g 33.1 g
Lithium carbonate Li_2CO_3 73.89	0.1 M	7.4 g
Lithium chloride LiCl 42.40	0.1 M	4.2 g
Lithium nitrate $LiNO_3$ 68.95	0.5 M	34.5 g
Magnesium bromide $MgBr_2 \cdot 6H_2O$ 292.25	0.1 M	29.2 g
Magnesium chloride $MgCl_2 \cdot 6H_2O$ 203.33	0.1 M	20.3 g
Magnesium hydroxide $Mg(OH)_2$ 58.34	saturated	300 g†
Magnesium nitrate $Mg(NO_3)_2 \cdot 6H_2O$ 256.43	0.1 M	25.6 g
Magnesium sulfate $MgSO_4 \cdot 7H_2O$ 246.50	0.5 M 0.1 M	123.3 g 24.7 g
Manganous chloride $MnCl_2 \cdot 4H_2O$ 197.91	0.5 M	99.0 g
Manganous sulfate $MnSO_4 \cdot H_2O$ 169.01	0.25 M 0.1 M	42.3 g 16.9 g
Mercuric chloride $HgCl_2$ 271.50	0.25 M 0.10 M	67.9 g 27.2 g
Mercuric nitrate $Hg(NO_3)_2 \cdot H_2O$ 342.63	0.1 M	34.2 g in 50 mL conc. HNO_3*
Mercurous nitrate $Hg_2(NO_3)_2 \cdot 2H_2O$ 561.22	0.1 M	56.2 g in 100 mL conc. HNO_3*
Mercurous sulfate Hg_2SO_4 497.24	0.1 M	49.7 g in 30 mL 1 M HNO_3*
Nickel chloride $NiCl_2 \cdot 6H_2O$ 237.72	0.25 M 0.1 M	59.4 g 23.8 g
Nickel nitrate $Ni(NO_3)O_2 \cdot 6H_2O$ 290.82	1 M 0.2 M	290.8 g 58.2 g
Potassium bromide KBr 119.02	0.5 M 0.1 M	59.5 g 11.9 g
Potassium carbonate K_2CO_3 138.21	0.5 M 0.1 M	69.1 g 13.8 g
Potassium chloride KCl 74.56	0.5 M 0.1 M	37.3 g 7.5 g

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

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

§ Use 7.5 mL conc. HNO_3 to help dissolve.

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

HOW TO...

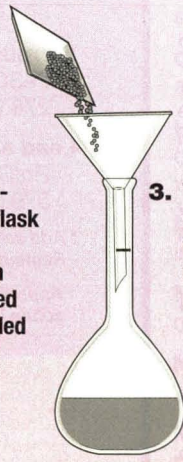
Make a Solution



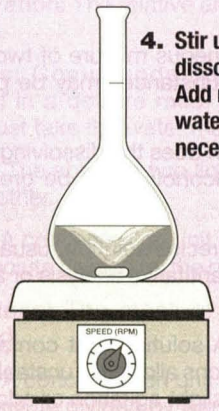
1. Weigh solid.



2. Fill volumetric flask ⅓–½ full with deionized or distilled water.



3. Transfer solid, wash out weighing dish.



4. Stir until dissolved. Add more water if necessary.



5. Add deionized or distilled water up to mark.

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Potassium chromate K_2CrO_4 194.21	0.1 M 0.5 M	19.4 g 97.1 g
Potassium dichromate $K_2Cr_2O_7$ 294.22	0.1 M	29.4 g
Potassium ferricyanide $K_3Fe(CN)_6$ 329.26	0.1 M 0.5 M	164.6 g 32.9 g
Potassium ferrocyanide $K_4Fe(CN)_6 \cdot 3H_2O$ 422.41	0.1 M	42.2 g
Potassium hydrogen phthalate $KHC_8H_4O_4$ 204.23	0.1 M	20.4 g
Potassium hydroxide see page 954		
Potassium iodate KIO_3 214.01	saturated 0.1 M	214 g† 21.4 g
Potassium iodide KI 166.01	1 M 0.5 M	166.0 g 83.0 g
Potassium nitrate KNO_3 101.11	0.5 M 0.1 M	50.6 g 10.1 g
Potassium permanganate $KMnO_4$ 158.04	0.2 M 0.1 M	31.6 g 15.8 g
Potassium phosphate, monobasic KH_2PO_4 136.09	0.1 M	13.6 g
Potassium phosphate, dibasic K_2HPO_4 174.18	0.1 M	17.4 g
Potassium phosphate, tribasic K_3PO_4 212.27	0.1 M	21.2 g
Potassium sulfate K_2SO_4 174.27	0.5 M 0.1 M	87.1 g 17.4 g
Potassium thiocyanate KSCN 97.18	0.1 M	9.7 g
Silver nitrate $AgNO_3$ 169.87	0.5 M 0.1 M	84.9 g 17.0 g
Sodium acetate $NaC_2H_4O_2 \cdot 3H_2O$ 136.08	1 M 0.5 M	136.1 g 68.0 g
Sodium bicarbonate $NaHCO_3$ 84.01	0.5 M 0.1 M	42.0 g 8.4 g
Sodium borate $Na_2B_4O_7 \cdot 10H_2O$ 381.42	4 %	40.0 g
Sodium bromide NaBr 102.90	0.1 M	10.3 g
Sodium carbonate Na_2CO_3 105.99	1 M 0.1 M	106.0 g 10.6 g
Sodium carbonate $Na_2CO_3 \cdot H_2O$ 124.00	1 M 0.1 M	124.0 g 12.4 g

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

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

PREPARATION OF SIMPLE INORGANIC SALT SOLUTIONS continued on next page.

General Solubility Rules for Inorganic Compounds

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

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

Chlorides (Cl^-): All chlorides are soluble except AgCl, $PbCl_2$, and Hg_2Cl_2. $PbCl_2$ is soluble in hot water, slightly soluble in cold water.

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

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

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

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

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

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

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

Preparation of Simple Inorganic Salt Solutions, continued

Name / Formula / F.W.	Concentration	g/L
Sodium chloride NaCl 58.45	saturated	390.0 g
	1.0 M	58.5 g
	0.1 M	5.8 g
Sodium dichromate $Na_2Cr_2O_7 \cdot 2H_2O$ 298.03	0.1 M	29.8 g
Sodium fluoride NaF 41.99	0.1 M	4.2 g

HOW TO...

Increase the Rate of Dissolving Solids

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

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

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

Sodium hydroxide see page 954

Sodium iodide NaI 149.92	0.5 M	75.0 g
	0.1 M	15.0 g
Sodium nitrate $NaNO_3$ 84.99	0.5 M	43.0 g
	0.1 M	8.5 g
Sodium oxalate $Na_2C_2O_4$ 134.00	0.1 M	13.4 g
Sodium phosphate, monobasic $NaH_2PO_4 \cdot H_2O$ 137.99	0.1 M	13.8 g
Sodium phosphate, dibasic $Na_2HPO_4 \cdot 7H_2O$ 268.07	0.5 M	134.0 g
	0.1 M	26.8 g
Sodium phosphate, dibasic Na_2HPO_4 141.96	0.5 M	71.0 g
	0.1 M	14.2 g
Sodium phosphate, tribasic $Na_3PO_4 \cdot 12H_2O$ 380.12	0.1 M	38.0 g
Sodium sulfate $Na_2SO_4 \cdot 10H_2O$ 322.19	1 M	322.2 g
	0.5 M	161.1 g
Sodium sulfate Na_2SO_4 142.02	1 M	142.0 g
	0.5 M	71.0 g
Sodium sulfide $Na_2S \cdot 9H_2O$ 240.18	2 M	48.0 g§
	1 M	24.0 g
Sodium sulfite Na_2SO_3 126.05	1 M	126.1 g
Sodium thiosulfate $Na_2S_2O_3 \cdot 5H_2O$ 248.19	0.5 M	124.1 g
	0.1 M	24.8 g
Stannous chloride $SnCl_2 \cdot 2H_2O$ 225.65	0.1 M	22.6 g in 13 mL 12 M HCl*
Strontium chloride $SrCl_2 \cdot 6H_2O$ 266.64	0.5 M	133.3 g
	0.1 M	26.7 g
Strontium hydroxide $Sr(OH)_2 \cdot 8H_2O$ 266.82	saturated	220 g†
Strontium nitrate $Sr(NO_3)_2$ 211.63	1 M	211.6 g
	0.5 M	105.8 g
Zinc chloride $ZnCl_2$ 136.29	0.5 M	68.1 g and 1 mL 12 M HCl*
	0.1 M	13.6 g
Zinc nitrate $Zn(NO_3)_2 \cdot 6H_2O$ 297.49	0.5 M	149.7 g
	0.1 M	29.7 g
Zinc sulfate $ZnSO_4 \cdot 7H_2O$ 287.56	1.0 M	287.6 g
	0.1 M	28.8 g

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

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

§ *Use hot water, stir vigorously.*

Distilled or Demineralized Water—Which Do I Need?

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

Preparation of Acid Solutions

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

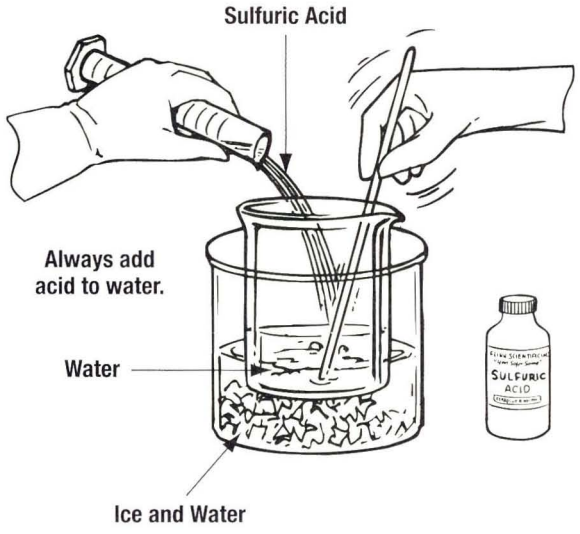
** Always add acid to water. The addition of acid to water is an exothermic reaction. Use high temperature (e.g., Pyrex®) glassware.*

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

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

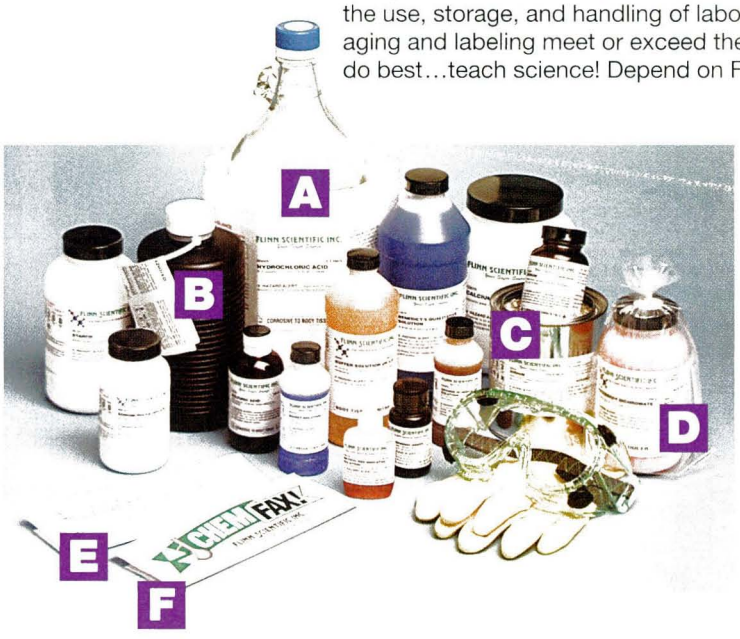
Preparing Sulfuric Acid Solution?

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



FLINN CHEMICALS make teaching science safer!

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



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

B Innovative packaging like the H_2O_2 accordion bottle and the *E-Z Drop*® bottle allow for safe storage and easy dispensing.

C Reactive metals are packaged in PVC-coated glass bottles and placed in special metal cans for safe storage.

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

E Specifically designed MSDS for science teachers included with every chemical.

F Many chemicals come with a ChemFax describing an interesting new lab, demonstration, or procedure.

Preparation of Base Solutions

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

** Use concentrated (14.8 M) ammonium hydroxide.*

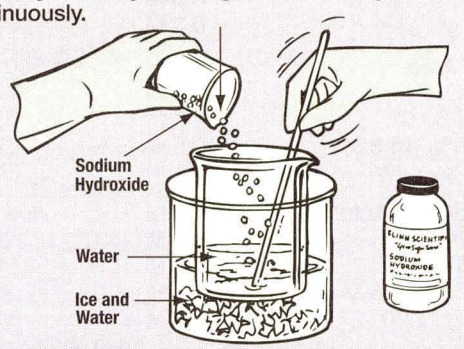
† Exothermic reaction. Use high temperature (Pyrex®) glassware.

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

Sodium Hydroxide and Heat

Preparing Sodium Hydroxide Solution?

A great amount of heat is liberated when sodium hydroxide and water are mixed. The temperature of the solution may rise very rapidly. In fact, the temperature may rise so fast that the solution may boil and possibly spatter a hot, caustic solution. Consider immersing your mixing vessel in a bucket of ice to control the solution temperature. In addition, pay special attention to the condition of the vessel you use to prepare these solutions. If you use a glass vessel it must be Pyrex® and it must be free of any scratches, chips or breaks. Inspect the vessel very, very carefully. Add ingredients slowly while stirring continuously.



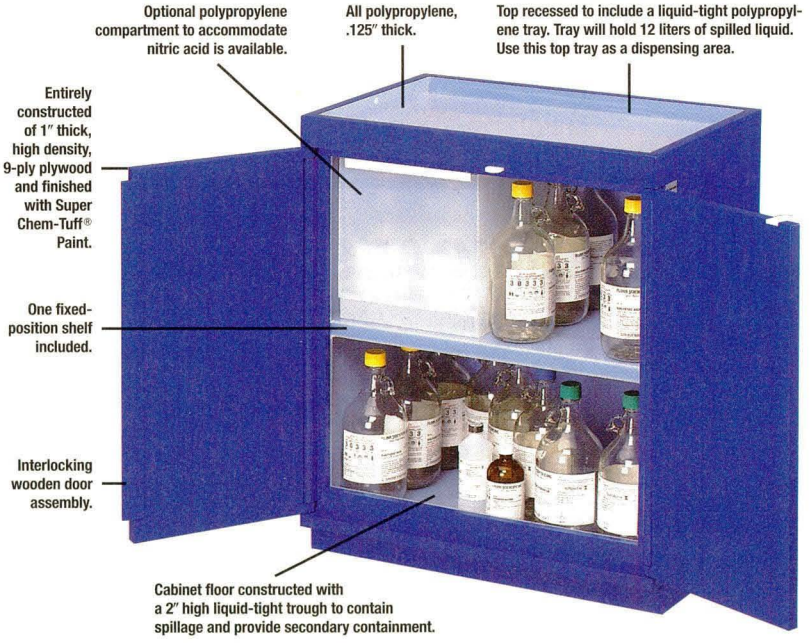
Safe Storage of Acids

Flinn/SciMatCo Wooden Acid Cabinets are Ideal for School Storerooms

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

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

Flinn acid cabinets will provide long life and safe, secure storage for all your corrosives. See pages 865–868 for more information.



Flinn Acid Cabinets

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

Catalog No.	Description	Price/Each
SE8041	Flinn Acid Cabinet; Wood; interior PARTIALLY lined with polypropylene (floor, shelf and top tray)	**$591.95***
SE8051	Flinn Acid Cabinet; Wood; interior COMPLETELY lined with polypropylene (floor, interior walls, interior top and top tray)	**799.95***

* *Cabinet must be shipped by motor truck freight.*

Recipes for Biological, Histological, and Chemical Solutions

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

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

Acetylcholine Bromide
1/10,000 solution: Dissolve 0.01 g of acetylcholine bromide in 50 mL of DI water, dilute to 100 mL with DI water.

Acridine Orange
1% aqueous: dissolve 1 g of acridine orange in 50 mL DI water, dilute to 100 mL, stir and filter if necessary. (biological stain)

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

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

Agarose Gel
See page 583 for complete instructions.

See page 79 for a complete listing of culture media.

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

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

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

Alum Carmine
Mix 10 g carmine, 25 g ammoniacal alum and 500 mL DI water. Bring to boil, cool, filter and make up to 500 mL with DI water. (nuclear stain)

Aluminon
Dissolve 0.1 g of aluminon in 100 mL of DI water. (qualitative reagent for aluminum)

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

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

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

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

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

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

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

Benedict's Quantitative Solution
Dissolve 18.0 g of copper (II) sulfate pentahydrate in 100 mL of DI water and set aside. Dissolve 100.0 g of sodium carbonate anhydrous, 200.0 g

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

SAFETY TIP

Become a Label Fanatic!

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

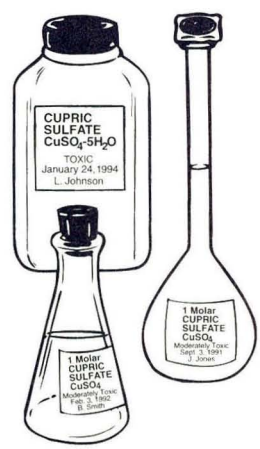
An unlabeled container will become tomorrow's "Mystery Substance." A grease pencil or label can help eliminate a future problem and a lot of expense.

YOU MAKE IT—YOU LABEL IT!

Minimum label requirements:

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





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

Bial's Reagent (Sumner)
Add 20 drops of 10% iron (III) chloride solution to 100 mL of 95% ethyl alcohol. Add 3 g of resorcinol and stir. (test for pentoses and glycuronic acids)

Bile Salts
5% aqueous: Dissolve 5 g of bile salts in 50 mL of DI water, dilute to 100 mL. Mix gently to avoid foam.

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

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

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

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

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

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

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

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

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

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

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

See page 101 for a complete listing of indicators and pH ranges.

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

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

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

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

HOW TO...

Prepare Buffer Solutions

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

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

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

pH 10: Prepare 0.025 M sodium borate solution by dissolving 2.38 g in 250 mL of DI water. Prepare 0.20 M sodium hydroxide solution by dissolving 0.8 g in 100 mL DI water. Mix 250 mL of the 0.25 M sodium borate solution and 27 mL of the 0.2 M sodium hydroxide solution, then dilute to 500 mL.

Recipes for Biological, Histological, and Chemical Solutions, continued

Bromine Water
Add 1 mL of bromine to 200 mL of DI water and stir. Keep in a tightly sealed bottle. The shelf life is poor due to evaporation of bromine.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Note: DI water denotes either distilled or deionized water.

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

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

See page 101 for a complete listing of indicators and pH ranges.

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

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

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

RECIPES continued on next page.

HOW TO...

Set Up a Prep Room

Equipment

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

Safety Essentials

- **Eyewash/Body Drench**
- **Spill Control and Clean-up Materials**
- **Fire Extinguisher**
- **Chemical-resistant gloves and aprons**
- **Chemical Splash Goggles**
- **Telephone available for emergency use**
- **Chemical First Aid Kit**
- **Good Ventilation**

See page 970 for a model storage/prep room diagram.

Recipes for Biological, Histological, and Chemical Solutions, continued

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

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

Can't find a solution recipe? Contact Flinn's Technical Service staff at techhelp@flinnsci.com.

Fehlings Solution B
Dissolve 125 g of potassium hydroxide and 173 g of potassium sodium tartrate tetrahydrate in 500 mL of DI water. (test for reducing sugars and aldehydes)

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

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

Preparing an Iodine Solution?

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

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

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

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

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

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

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

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

Gastric Juice
Dissolve 5 g pepsin, 8.75 g conc. hydrochloric acid, and 2.5 g of lactic acid in 500 mL of DI water. Dilute to 1 L and stir gently to avoid foaming.

Gibberellic Acid
Dissolve 100 mg of gibberellic acid in 5.0 mL of ethyl alcohol. Dilute to 1 L with DI water.

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

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

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

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

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

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

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

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

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

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

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

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

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

Recipes for Biological, Histological, and Chemical Solutions, continued

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

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

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

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

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

Methyl Green
1% alcoholic: Dissolve 1 g of methyl green in 75 mL of 95% ethyl alcohol, then dilute to 100 mL with 95% ethyl alcohol. Stir, filter if necessary. Use 70% ethyl alcohol if stain is for plant tissue. (stain for plant tissue and supravital stain for small organisms)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

HOW TO...

Slow Microorganisms

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

Recipes for Biological, Histological, and Chemical Solutions, continued

Phenolphthalein
1% alcoholic: Dissolve 1 g of phenolphthalein in 50 mL of 95% ethyl alcohol, then dilute to 100 mL with 95% ethyl alcohol. (pH indicator)

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

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

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

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

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

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

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

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

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

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

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

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

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

Safranin O
Dissolve 0.25 g stain in 10 mL of ethyl alcohol, then add 100 mL of DI water. Filter before use. (Gram counter stain)

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

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

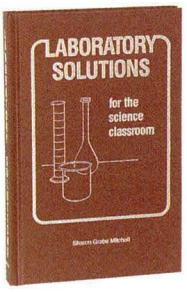
Seawater
Dissolve 29.42 g of sodium chloride, 0.5 g of potassium chloride, 3.22 g magnesium chloride, 0.56 g sodium bromide, 1.36 g calcium sulfate, 2.4 g magnesium sulfate, 0.11 g calcium carbonate, 0.003 g ferric oxide in 1 L DI water. Not for aquaria, only for technical purposes.

Note: DI water denotes either distilled or deionized water.

RECIPES continued on next page.

Laboratory Solutions for the Science Classroom

The Teacher's Handbook to Solution Preparation



Need a more complete guide on solution preparation? *Laboratory Solutions for the Science Classroom* has been the science teacher's #1 handbook for years. Includes explanations of basic concepts and vocabulary terms, detailed recipes of over 300 commonly used solutions, and practical solution-making techniques.

Recipes cover biology (culture media and biological stains), chemistry and physical science solutions used in high schools. If you happen to come across a solution for which a recipe is not included, then the explanation section of the book will guide you through the steps of determining the correct procedure for making the solution.

This reference book is a must for all science teachers! Illustrated, Appendices, Glossary, Index. 1991, 189 pages, 5¾″ × 8¾″, hard cover.

Catalog No.	Description	Price/Each
AP8858	Laboratory Solutions for the Science Classroom	$34.60

Recipes for Biological, Histological, and Chemical Solutions, continued

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

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

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

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

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

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

TBE/TAE Buffer
See page 581 for complete instructions on how to prepare these electrophoresis buffers.

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

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

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

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

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

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

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

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

Wright's Stain
Dissolve 2.5 g of Wright's stain in 75 mL of absolute methyl alcohol, then dilute to 100 mL with absolute methyl alcohol. Stir and filter if necessary. (biological stain for blood)

Note: DI water denotes either distilled or deionized water.

Now, an affordable milligram balance!

Save time and improve accuracy with Flinn's new top-loading milligram balance.



With a capacity of 99 g and 0.001 g precision, it's perfect for prep rooms and solution making. See page 181 for further details.

Catalog No.	Description	Price/Each
OB2060	Flinn 1 mg Electronic Balance	$404.05

SUGGESTIONS FOR THE TAKING OF A CHEMICAL INVENTORY IN A SCHOOL SCIENCE DEPARTMENT

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

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

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

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

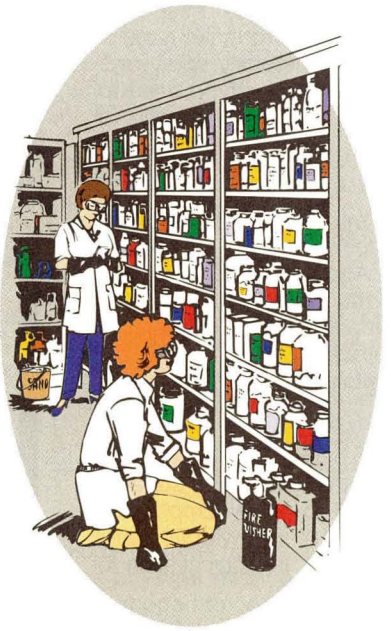
It is very important to point out that laboratory chemicals should ***no longer be purchased like other routine school supplies!*** The normal routine of most schools is to acquire a year's supply of needed chemicals at one time, along with other routine science supply needs. The result of this process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

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

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

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

It is not uncommon to find, among multiple school buildings, an excess of a chemical in Building A while the science teacher in Building B just placed an order for the very same chemical. Why can't inventories be shared with the goal in mind of better



systemwide substance management? If the impediment to better, safer and more efficient substance management is the "established system" or the "established bureaucracy" then the "system" or the "bureaucracy" must be educated and their methods changed. Would you not agree that an efficient method of substance management in a multiple science department building or in multiple buildings is to provide inventory level information to all users and allow all users access to excess inventories? No, one school should not be allowed to rob another school's inventory. However, can't excesses be identified and shared? The science teacher who is a good substance or inventory manager should not be penalized to serve the poor

Continued on next page.

manager in another department or building. Conventional wisdom suggests, however, that excess substances can be better managed by sharing knowledge of their existence.

You have now decided it is time to take an inventory. Plan for the event using the Inventory Planning Checklist below.

A very effective means of taking and temporarily recording your inventory is by means of portable dictation equipment. Perhaps you can find, at the school or at home, a battery-operated recording device. It would be ideal if the device could be placed in your pocket or attached to your person along with a microphone that would hang around your neck or be attached to your collar. This would free both hands so you can have maximum flexibility in moving about the storeroom.

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

Continued on next page.

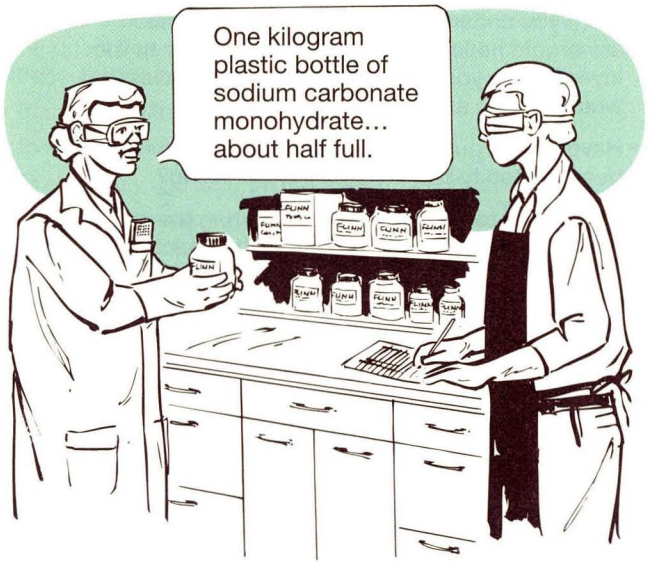
Inventory Planning Checklist

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

CHEMICAL INVENTORY *continued*

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

With your recording equipment operable you now start across your shelves. You recite into the recording equipment the full name of each substance, the approximate size of the container and the amount of the contents. A typical recording might sound like, "One 5-lb. bottle, glass container, of acacia, about one-half full." If you wish, you might want to spell the name of each substance. Some schools turn this tape over to their business training department for typing. If a non-technical person would, at some later time, be called upon to transcribe this data you must be articulate and spell the name of each substance. Such detail only takes a matter of seconds on your dictating tape.



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

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

If your shelves and cabinets are just loaded and a lot of movement of substances is required to inventory all the materials, then the task will require several hours. If however, most substances can be viewed and recorded with little bottle shifting or relocation then even a very large high school chemical stores facility will not require much more than about 2–2½ hours to record all of these substances on your tape. The use of a portable, battery-operated, necklace microphone recording instrument is a very efficient means of rapidly concluding this part of the process.

Your next step is to transcribe this information into hard copy. That copy may take the form of 3″ × 5″ cards, sheets of paper, etc. You may even wish to consider acquiring the Flinn computer chemical inventory system (see page 904).

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

Flinn Hazard Caution Codes

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

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

Your next step would be to decide what stays and what goes in this total inventory. We urge you to be ruthless in ridding your premises of these unused and unneeded chemicals. In fact, when you have made the decision about ridding yourself of many substances, then consider getting those items off your shelf first. No, do not simply acquire some cartons and pile bottle upon bottle into cartons and create a new problem. Rather, use your conventional wisdom and ask yourself if the item is hazardous and then investigate its hazardous character.

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

Should it be physically isolated? An example please. Let's assume you find a 500-gram bottle of aluminum chloride, anhydrous, and you wish to rid yourself of this substance. You do not know how to achieve this but you want it off the shelf and yet protected and safe for later disposition. Place the bottle in three thicknesses of Baggies®. You can get Baggies at your local grocery store. Flinn has heavy duty plastic bags called *Chem-Saf*® Bags for this purpose. You will find *Chem-Saf*® Bags listed on page 887 in this Catalog/Reference Manual. Next, acquire some clean, never-used, one-quart and one-gallon paint cans. Flinn has such containers called *Saf-Stor*® Cans. These are also listed on page 887 in this Catalog/Reference Manual. You can acquire similar cans (less heavy duty) at a local paint store or store that might sell and mix paints to order.

Continued on next page.

FLINN COMPATIBLE CHEMICAL FAMILY CODES

When you assign compatible chemical family data you may wish to use the system created by Flinn. The family designations are listed below and in more detail on the following pages. Family designations for individual chemicals are found in the individual chemical listings of this Catalog/Reference Manual.

Flinn Organic Compatible Family Codes

- O1 – Acids, Amino Acids, Anhydrides, Peracids
- O2 – Alcohols, Glycols, Sugars, Amines, Amides, Imines, Imides
- O3 – Hydrocarbons, Esters, Aldehydes, Oils
- O4 – Ethers, Ketones, Ketenes, Halogenated Hydrocarbons, Ethylene Oxide
- O5 – Epoxy Compounds, Isocyanates
- O6 – Peroxides, Hydroperoxides, Azides
- O7 – Sulfides, Polysulfides, Sulfoxides, Nitriles
- O8 – Phenols, Cresols
- O9 – Dyes, Stains, Indicators
- OM – Miscellaneous

Flinn Inorganic Compatible Family Codes

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

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

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

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

Those substances which remain on your shelves can now be reorganized into their compatible chemical families. We urge that you review all the details of appropriate and safe storage in the section of this Catalog/Reference Manual dedicated to that subject.

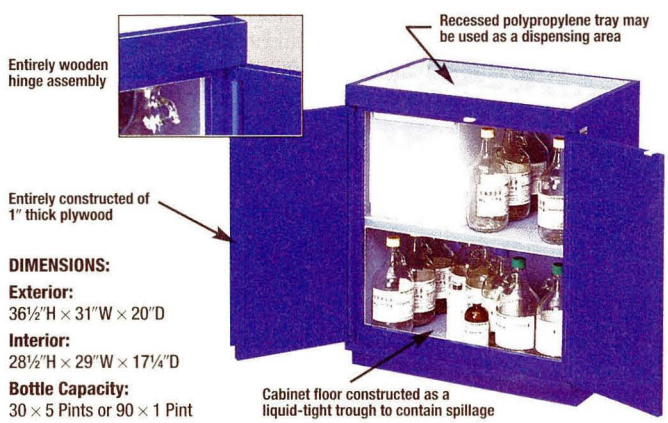
Avoid distractions.

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

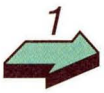
Here's the Last Acid Cabinet You'll Ever Need!

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

Catalog No.	Description	Price/Each
SE8041	Flinn Acid Cabinet. Interior partially lined with polypropylene.	$591.95
SE8051	Flinn Acid Cabinet. Interior fully lined with polypropylene.	799.95
SE8071	Nitric Acid Compartment. Polypropylene.	98.50



SUGGESTED SEQUENCE OF STEPS TO MORE SAFELY ORGANIZE YOUR SCHOOL'S CHEMICAL STORES AREA



Take an inventory of the chemicals on your premises. You will never know the extent of your problem until you know exactly what you have. Record the inventory. You may want to consider the purchase of the FLINN CHEMICAL INVENTORY SYSTEM to facilitate this task.



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



Reorganize the remaining products into their compatible chemical families (see our Suggested Chemical Storage Pattern on page 967). The actual sequence of compatible families on your shelves is not critical. What is important is to keep the compatible families separate and to keep the organic and inorganic families as far apart as possible. The Suggested Shelf Storage Pattern shown on pages 968–969 is only one suggested sequence you can use. If shelf space is a problem, you are permitted to place more than one compatible family on a shelf. Make sure you either have a physical divider or leave a 3″ space between each family.

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

Inorganic Families

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

Families	Percentage of Shelf Space Occupied
Sulfides, etc. (Inorganic 5)	Less than 1%
Chlorates, Perchlorates, etc. (Inorganic 6)	5+%
Arsenates, etc. (Inorganic 7)	Less than 1%
Borates, Chromates, etc. (Inorganic 8)	Less than 1%
Sulfur, Phosphorus, etc. (Inorganic 10)	Approximately 3%



And Organic Families

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



And Other Materials

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



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

- store compatible products together
- separate acids into dedicated storage
- separate flammables into dedicated storage
- lock up all poisons
- record all inventory
- rid yourselves of excess materials

YOU NOW HAVE A SAFER FACILITY

SUGGESTED CHEMICAL STORAGE PATTERN

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

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

Inorganic

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

Organic

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

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

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

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

SUGGESTED SHELF STORAGE PATTERN—INORGANIC

INORGANIC #10
Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide

INORGANIC #2
Halides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens, Acetates

INORGANIC #3
Amides, Nitrates (not Ammonium Nitrate), Nitrites, Azides
(Store Ammonium Nitrate away from all other substances—*ISOLATE IT!*)

INORGANIC #1
Metals & Hydrides
(Store away from any water.)
(Store flammable solids in flammables cabinet.)

INORGANIC #4
Hydroxides, Oxides, Silicates, Carbonates, Carbon

If possible avoid using the floor.

INORGANIC #7
Arsenates, Cyanides, Cyanates
(Store away from any water.)

INORGANIC #5
Sulfides, Selenides, Phosphides, Carbides, Nitrides

INORGANIC #8
Borates, Chromates, Manganates, Permanganates

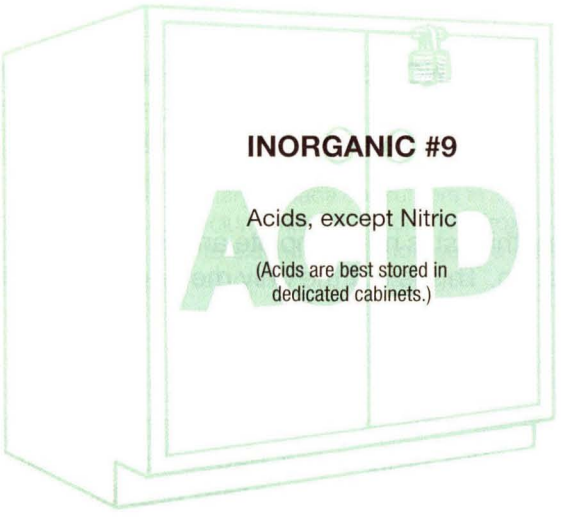
INORGANIC #6
Chlorates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, Perchloric Acid, Peroxides, Hydrogen Peroxide

MISCELLANEOUS

Storage Suggestions

1. Avoid floor chemical storage (even temporary).
2. No top shelf chemical storage.
3. No chemicals stored above eye level.
4. Shelf assemblies are firmly secured to walls. Avoid island shelf assemblies.
5. Provide anti-roll-off lips on all shelves.
6. Ideally, shelving assemblies would be of wood construction.
7. Avoid metal, adjustable shelf supports and clips. Better to use fixed, wooden supports.
8. Store acids in dedicated acid cabinet. Store nitric acid in that same cabinet **only** if isolated from other acids. Store both inorganic and some organic acids in the acid cabinet.
9. Store flammables in a dedicated flammables cabinet.
10. Store severe poisons in a dedicated poisons cabinet.

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



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

SUGGESTED SHELF STORAGE PATTERN—ORGANIC



ORGANIC #2
Alcohols, Glycols, etc.

ORGANIC #3
Hydrocarbons, etc.

ORGANIC #4
Ethers, Ketones, etc.

ORGANIC #9
Alcohol-based Indicators, etc.

Store severe poisons in locked Poisons Cabinet.

HOW TO...

Maximize Storage Space

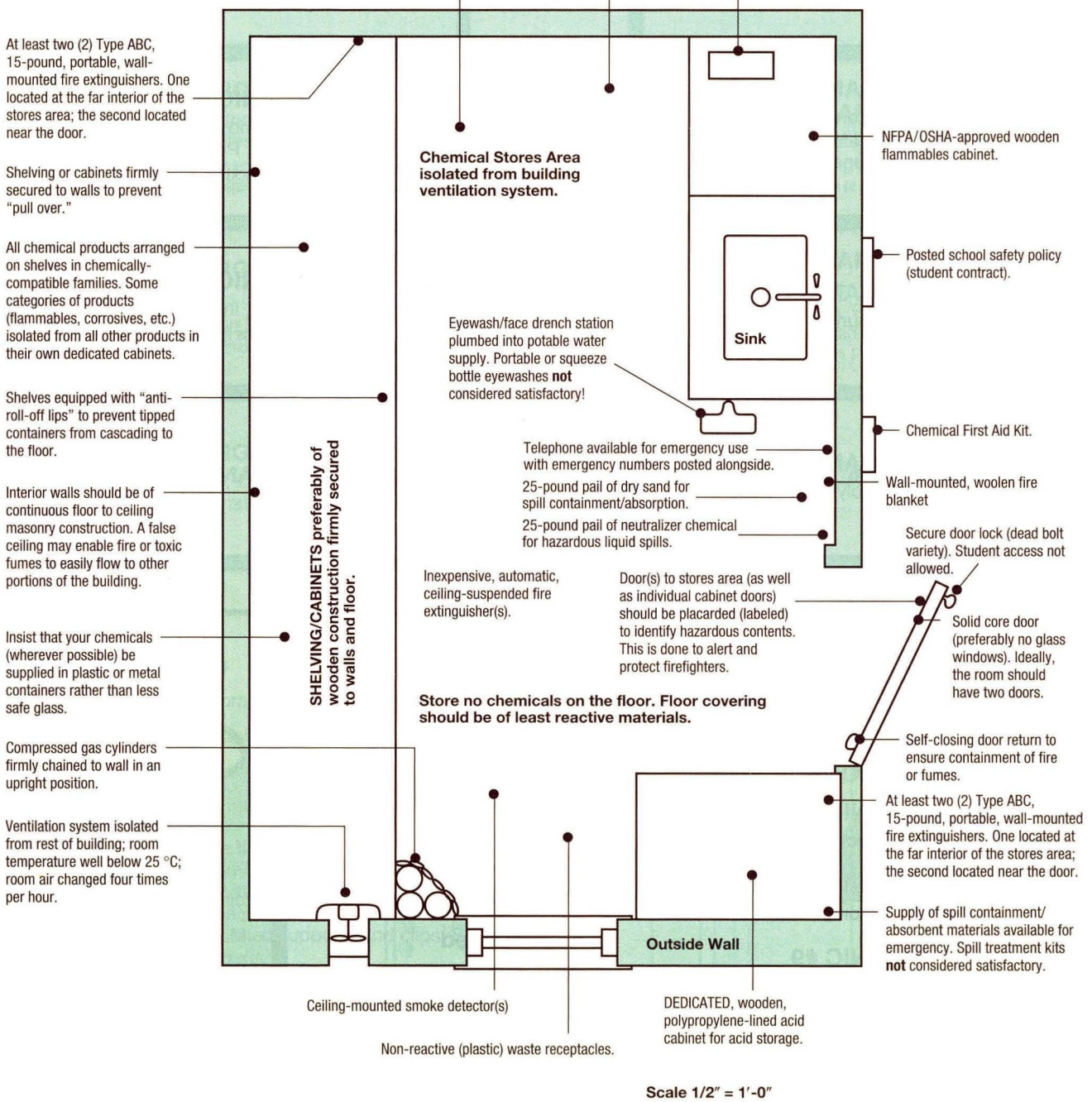
If shelf space is a problem, you are permitted to place more than one compatible chemical family on a shelf. Make sure you either have a physical divider or leave a 3″ space between each family. This will maximize your tight shelf space while keeping each compatible chemical family separate from one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

See page 966 for complete instructions on organizing your chemical stores area.

MODEL CHEMICAL STORES AREA

Please compare your facility to this model.

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



Scale 1/2" = 1'-0"

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

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

17 Steps to Minimize Chemical Waste

Smart, Inexpensive Practices to Avoid Chemical Disposal

The single largest chemical problem facing schools today is chemical disposal. The chemical disposal problem at your school started the day the school was built. The purchasing of chemicals in large package sizes, poor chemical inventory management, teacher turnover, and changes in science curriculums are just a few of the many reasons why your school may have a chemical disposal problem. What every school needs is a plan to minimize future chemical wastes. Chemical disposal is a necessary part of any chemical laboratory activity. The following 17 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.** Chemicals remain fresh longer when stored 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 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. Imagine the quality of reducing agents after being exposed to a continuous environment of chlorine gas.
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 (e.g., old peanut butter jars or soda bottles) 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 the container and greatly lengthens shelf life.
11. **Follow good laboratory practices.** Never allow students to place chemicals back into a chemical reagent bottle. Contamination from student use will dramatically reduce purity and the shelf life of a chemical. To enforce this rule, place smaller amounts of chemicals in beakers or bottles for dispensing.
12. **Never accept donations of chemicals.** These donations are usually of unknown age and unknown purity—why accept someone else's garbage? Buy your own chemicals fresh for best results and longest shelf life.
13. **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).
14. **Purchase chemical demonstration kits or chemistry student 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.
15. **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.
16. **Dispose of waste chemicals immediately after they are generated.** Do not stockpile unwanted products or other laboratory wastes. Disposal of small quantities of chemicals is easier and quicker than stockpiling them for a massive disposal at the end of the year.
17. **Keep waste solutions separate.** Never mix wastes from different labs unless the wastes have identical disposal methods. Adding a small amount of a lead compound to a waste crock necessitates treating the entire waste crock as a lead solution.

Implementing and following these 17 steps to minimize chemical waste will save money and improve the overall safety profile of your school.

BEFORE YOU UNDERTAKE LABORATORY CHEMICAL DISPOSAL—READ THIS NARRATIVE!

Specific federal, state and local regulations may apply to ridding your school of excess and unwanted chemicals. Before you select any disposal option, it is absolutely essential that you review your selected option(s) with regulatory officials. Do not assume that because we publish a group of disposal methods, therefore, these methods are "approved" or that the methods have the "blessing" of regulatory officials—NOT SO! We publish these methods because we assume the quantity of material(s) involved is very small (laboratory quantities); we assume that only competent science teachers will attempt these methods; we assume you will consult with local regulatory officials before proceeding and because we know you will act responsibly. If these methods do not meet local regulations, DO NOT USE THEM! If you are not comfortable with the chemistry of the methods, DO NOT USE THEM! If the quantity of material is not small (i.e., laboratory quantity), DO NOT USE THESE METHODS!

What are your options? Let us examine disposal options.

OPTION A — Contact your state department of education. Many states have a state science supervisor who may be able to make suggestions or advise you about existing programs already operating. We maintain a current list of state science administrative personnel. Write or telephone us for the name and address of your state contact.

OPTION B — If your school is located in an area near a college or university, that institution's chemistry department may be able to advise you about the disposal methods they employ. You will want to prepare a complete list of the substances you consider excess. There is a chance the college may be able to use some of these materials. No, do not foist your junk off on someone else. Be straightforward with neighboring colleagues and this may prove helpful.

OPTION C — Have you shared your list of excess materials with other schools in your system or other neighboring schools? Assuming some of the chemicals involved are still useful, perhaps another school can use what you consider excess.

OPTION D — Contact your state equivalent of the federal Environmental Protection Agency (EPA). Most states have a state EPA. Discuss the problem with this agency. Perhaps they have valuable suggestions.

OPTION E — Try to contact an officer of your state's science teachers' professional association. Most states have organized science teachers' groups. Other teachers have faced problems similar to yours. Bring their experience to bear on solving your problem.

OPTION F — In many metropolitan areas, there are local sections of the American Chemical Society (ACS). Any area with a lot of chemical industries is likely to have a local ACS section. Contact these professionals. They may have some helpful insights.

If all of these options prove fruitless, you are left with two options:

OPTION G — Pay a commercial firm to assist in removing these materials. This is a very, very expensive option. Be sure you ask for references from such a commercial firm. There are reputable and reliable firms operating all over the USA. Just be careful in making your choice.

OPTION H — Do the disposal work yourself. If you elect this option, you will want to examine the disposal methods provided in this edition of the *Flinn Scientific Catalog/Reference Manual*.

Do not act in haste. It will take some time to properly package many of the hazards on your shelf—that will allow time to examine your options.

If you have elected to use the disposal methods published here, there are some further considerations that need your attention. These considerations are:

1. Have you checked with regulatory officials in your area regarding these procedures? DO NOT—we repeat—do not use these procedures if local regulatory officials have not approved.

2. You will need to make a list of the safety aids needed for these procedures: e.g., fume hood, apron, chemical splash goggles, fire extinguisher, gloves, etc.

3. Never work alone! Find a competent assistant and proceed to work as a team.

4. If a particular method is confusing or you are not familiar with the chemistry involved, do not proceed. Call us—we will be glad to help.

5. Do some practical cost analysis. In many cases, the procedures require the use of large quantities of neutralizing chemicals and other expensive materials. In the final analysis, you may find that your cost analysis may cause you to go back and examine disposal option G (i.e., pay a commercial firm to remove the chemicals).

6. Always practice your intended disposal activity on a tiny (micro) sample of the targeted substance before moving on to handle the larger (macro) volume. A reaction that liberates enormous amounts of heat may require that your reaction vessel be immersed in an ice bath to better control the reaction temperature. You will only make these discoveries if you "practice" with a very small sample before proceeding.

7. All of these procedures are best done in a very well ventilated laboratory and preferably in a well maintained, efficient fume hood. If you elect to perform a procedure out of doors, then stay upwind of the reaction and be sure your activities do not disturb or threaten your school's neighbors.

8. Make a checklist of all items needed for a particular method before you start the procedure. Have all materials at hand and immediately available.



Did You Know It Is Always Yours?

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

SUGGESTED LABORATORY CHEMICAL DISPOSAL PROCEDURES

No representation, warranty or guarantee is made by Flinn Scientific Inc. as to the accuracy or completeness of our suggestions or information. Local conditions or circumstances unique to your particular situation (applicable federal, state or local law) should be considered.

We repeat and admonish you to recognize the need to carry out these suggested procedures with proper personal safety equipment and in a proper environment. You should wear chemical-resistant gloves, chemical splash goggles and a chemical-resistant apron at all times. It would be best if these procedures were done under a fume hood. Failing that, certainly adequate ventilation should be provided or the procedure done out of doors. Stay upwind of these outdoor reactions and be certain that your activities are in an isolated area and present no hazard to your neighbors. Make a checklist of the materials you will need before you start a procedure. We emphasize that you should never be alone while disposing of hazardous materials and that a telephone or other form of communication be available for immediate use.

Please contact us if we can help you further. Write: Technical Service Department, Flinn Scientific, Inc., P.O. Box 219, Batavia, Illinois 60510-0219. Phone 800/452-1261. E-mail: flinn@flinnsci.com.

Each chemical in the *Flinn Scientific Catalog/Reference Manual* has a disposal number listed under its name. This disposal number refers to one of the suggested disposal techniques listed below. Simply look up the product in the alphabetical section of the chemical listings and determine the disposal number. Then refer to this disposal technique number and follow the suggested procedure.

Disposal of Materials Not Covered in This Catalog/Reference Manual

Are there materials for which you would like disposal help but are not found in the *Flinn Scientific Catalog/Reference Manual*? If so, please write to our technical service department providing the full chemical nomenclature of the material and the quantity involved. We are best equipped to help you via mail rather than telephone—except, of course, in the case of an emergency.

Disposal Method Concepts

Some of the Flinn disposal methods involve knowing something about the stoichiometry of the chemistry involved. As a preface to this set of concepts, it is worthwhile to briefly discuss stoichiometry.

Stoichiometry refers to the relationships between quantities of substances involved in a chemical reaction. These quantities are related by a "balanced chemical equation" which expresses, in a chemist's shorthand, the nature and amount of chemicals that can react with each other. For example, we know that the elements hydrogen and oxygen can combine to form the compound water. We know the formulas for these three substances: hydrogen and oxygen each have two atoms per molecule, and water is a compound with two atoms of hydrogen and one atom of oxygen per molecule. We can write a balanced chemical equation to express this:

$$2H_2 + O_2 \rightarrow 2H_2O$$

This means that two molecules of diatomic hydrogen react with one molecule of diatomic oxygen to form two molecules of water. This equation may be generalized to say that the ratio of the molecules involved is 2:1:2. Atoms and molecules are essentially impossible to deal with on an individual basis, since they are so small and weigh so little. Chemists, therefore, deal in a quantity called the MOLE. A mole is a counting unit, just as the term dozen is a counting unit. While a dozen refers to the number 12, the mole refers to the number 6.023×10^{23}. This number is almost unimaginably large, but that need not confuse the concept. Just as three dozen eggs refers to 36 eggs, three moles of eggs would refer to about 18×10^{23} eggs. So our equation above, since it deals in ratios of numbers, also tells us that two moles of hydrogen react with one mole of oxygen to form two moles of water.

Why define a mole as 6×10^{23} units of something? Chemists have chosen this number only because it is convenient. It is convenient because it provides a useful weighing unit for chemicals. Although one cannot weigh a single molecule of hydrogen, one can easily weigh a mole of hydrogen molecules, or any other molecule, in the laboratory. The molar quantity was chosen so that weighing that number of molecules would give a number, expressed in grams, that is identical to the molecular weight of the substance involved. So, for water which has a molecular weight of 18 (two atoms of hydrogen at approximately 1 per atom plus one atom of oxygen at about 16), weighing out a mole of water molecules yields a mass of 18 grams. At least that's what we say we do; actually what we do is weigh out 18 grams of water and assert (without counting the individual molecules) that we have 6.023×10^{23} molecules in our 18-gram sample of water.

Now it is clear that our balanced chemical equation relates not only the numbers of atoms and molecules that are involved, but also their relative weights. In our example involving the formation of water, it may be interpreted as saying that 4 grams of hydrogen (2 moles of H_2) react with 32 grams of oxygen (1 mole of O_2) to form 36 grams of water (2 moles of H_2O). But, since these are ratios we're discussing, the same equation also says that 100 grams of hydrogen reacts with 800 grams of oxygen to form 900 grams of water. This may be generalized to all balanced chemical equations, of course.

The importance of these concepts to proper chemical disposal is this: If you wish to dispose of a chemical, and the disposal method involves a chemical reaction, you must know how many moles of this chemical you wish to dispose of, and provide enough moles of any other chemicals involved in the reaction to provide complete conversion of the target chemical to a more innocuous form. You can determine the weight of this target chemical in grams, divide this number by the molecular weight of the chemical, and the result will be the number of moles of substance you must dispose of. Then you use the balanced chemical equation (given in each of the disposal concept discussions that precede each disposal technique) to determine the minimum amount of other reactants needed. Usually the disposal procedures will specify something like "a two-fold molar excess," which means that you should use at least twice as many moles of the other reactant as the minimum you have calculated. The reasons for the excess are to make sure complete conversion has occurred and to speed up the rate of conversion of the hazardous chemical to the less hazardous form.

As has been said in other locations in the *Flinn Scientific Catalog/Reference Manual*, if you are not comfortable doing these calculations, please consult with a more knowledgeable person before attempting to perform these disposal procedures.

The chemical concept of each disposal method will follow the title "Material Required" for each suggested method. As you review the method you will, if you wish, have the opportunity to learn about the "chemistry" of the suggested method.

It would also be wise for the science teacher about to follow these procedures, to calculate the cost of chemicals necessary to react the substances involved in disposal. The cost of chemicals to perform disposal, plus your time and labor, may favor having the disposal handled by a disposal service firm.

Be sure that you consider "experimenting" with a particular procedure using a very small quantity of the substance. Such "practice"

Continued on next page.

DISPOSAL METHOD CONCEPTS

Continued from preceding page.

will enable you to anticipate and experience potential problems on a small scale while the consequences are well within your control.

Disposal of certain chemical wastes is governed by the Resource Conservation and Recovering Act (RCRA). Local jurisdictions frequently impose even more restrictive regulations. It is important that you learn those local regulations and abide by them.

Disposal Procedures

FLINN METHOD

#1a ORGANIC ACID HALIDES AND ACID ANHYDRIDES

Products in this class readily react with water, amines, and alcohols. They should never be allowed to come into contact with wastes that contain such substances. They are also generally corrosive and their vapors are lachrymators. Most organic acid halides can be decomposed to water-soluble products of low toxicity that can be flushed down the drain. Heat may be liberated during this process. The heat can be controlled by immersing the reaction vessel in a larger container of ice water.

EXAMPLES:

Acetyl chloride, adipoyl chloride, and acetic anhydride

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood or excellent ventilation
Large glass or polyethylene container
Saturated solution of sodium carbonate (200 g $NaCO_3$/L), enough for twofold molar excess
Stirring rod
3 M hydrochloric acid
pH indicator paper
Ice-water bath (optional)

CHEMICAL CONCEPT:

Organic acid halides are derived from organic acids by replacing the ionizable hydrogen atom of the acid with a halogen atom, usually chlorine. These substances react with water to form the original organic acid and hydrogen chloride, both of which will usually dissolve in excess water and form an acidic solution. This is the reason these compounds are corrosive and are lachrymators: their vapors react with the tears (mostly water) that bathe your eye and make them acidic. The disposal method involves two simultaneous steps. The saturated sodium carbonate solution contains both water and a base, sodium carbonate. The organic acid anhydride or halide reacts with the water, and the products of that reaction, which are acidic, immediately react with the sodium carbonate to form salts of the acids. These salts are innocuous and may be flushed down the drain. Gaseous carbon dioxide also forms, which will produce a fizzing as the reaction proceeds.

In the case of acetyl chloride, the reactions are as follows:

$$CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$$

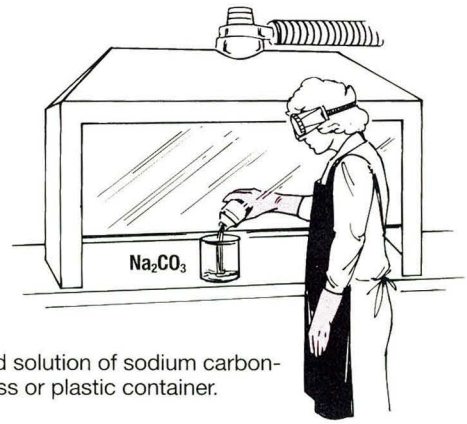
$$CH_3COOH + \tfrac{1}{2}Na_2CO_3 \rightarrow NaCH_3OO + \tfrac{1}{2}CO_2 + \tfrac{1}{2}H_2O$$

$$HCl + \tfrac{1}{2}Na_2CO_3 \rightarrow NaCl + \tfrac{1}{2}CO_2 + \tfrac{1}{2}H_2O$$

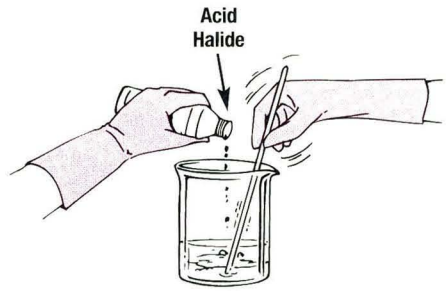
Note that one mole of sodium carbonate is required to fully neutralize one mole of the original acid halide or acid anhydride. There should be plenty of excess water in the saturated sodium carbonate solution to provide the initial reaction. To push the reaction to completion, a twofold molar excess 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) can be substituted for saturated sodium carbonate in this procedure.

Both adipoyl chloride and sebacoyl chloride contain two chlorines per molecule. Therefore a fourfold molar excess of sodium carbonate solution should be used to neutralize these compounds.

PROCEDURE:



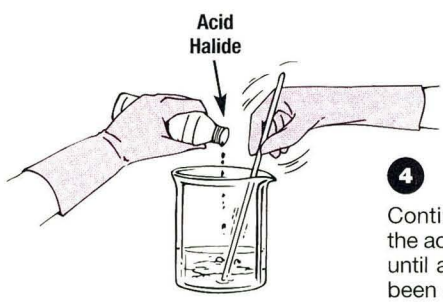
1 Place the saturated solution of sodium carbonate in the large glass or plastic container.



2 Slowly add a few milliliters or grams of the acid halide or anhydride to the container while constantly stirring. You can tell that the decomposition reaction is beginning if the material dissolves. The evolution of gaseous carbon dioxide should also be evident.

3 If a noticeable temperature rise is observed in the solution, place the container in the optional ice-water bath. This may occur with acetic anhydride.





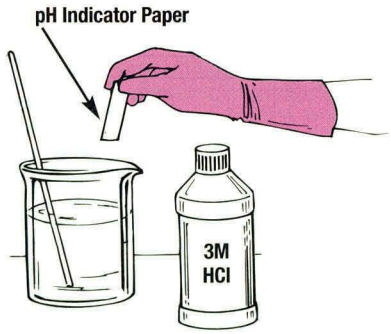
4 Continue slow addition of the acid halide while stirring until all the compound has been consumed.

FLINN METHOD #1a continued on next page.

Please...Read the Narratives

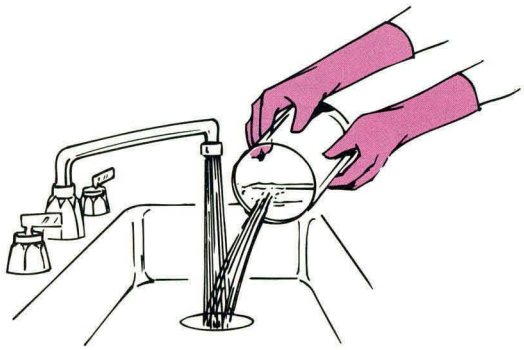
Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures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

FLINN METHOD #1a *continued*



5

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



6

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

FLINN METHOD #1b WATER-REACTIVE METAL HALIDES

Products in this class are quite reactive with water and evolve heat during the reaction. Such reaction products are strongly acidic. Water reactive metal halides must not be allowed to come into contact with wastes containing water. They can generally 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 stannic chloride

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood or excellent ventilation
Large glass or polyethylene container, ¾ filled with ice/water slush
Stirring rod
3 M sodium hydroxide solution or
saturated sodium carbonate solution
pH indicator paper

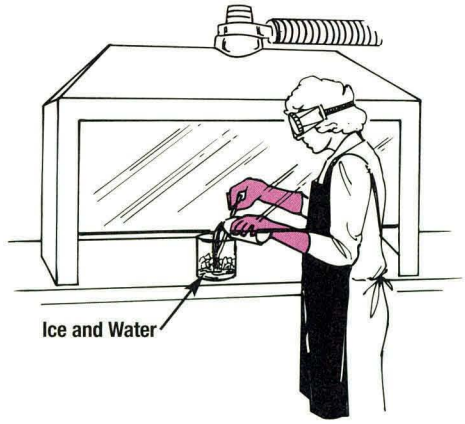
CHEMICAL CONCEPT:

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

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

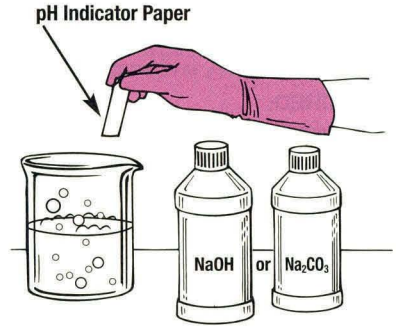
The HCl formed will dissolve in the excess water. It is neutralized with either sodium hydroxide (to form sodium chloride and water) or with sodium carbonate (to form sodium chloride, gaseous carbon dioxide and water).

PROCEDURE:



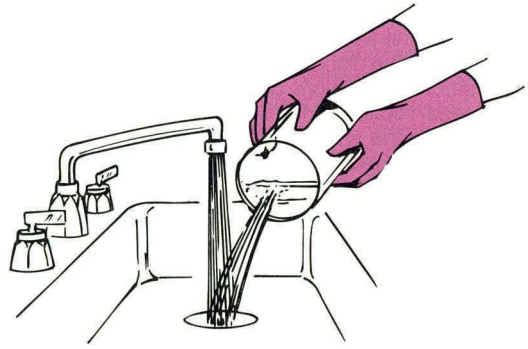
1

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.



2

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 stannic oxide will form.



3

Let the mixture settle overnight and then decant the liquid to the drain with a 20-fold excess of water. The solid residue can be disposed of in the trash.

FLINN METHOD

#2 ALDEHYDES

Products in this class may be solids, liquids, gases or aqueous solutions. We recommend simple evaporation for small amounts of low-boiling liquids and their aqueous solutions. Higher-boiling liquids and solids are flammable and incineration is a good option. Many jurisdictions will permit formaldehyde and acetaldehyde to be drain-disposed. Check with local authorities before proceeding to dispose of formaldehyde, formalin and acetaldehyde down the drain.

EXAMPLES:

Acetaldehyde and benzaldehyde

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood or outdoor site for evaporation
Large metal pan (for evaporation only)
1-L beaker
Thermometer
pH indicator paper
Magnetic stirrer/hot plate and stir bar
0.3 M potassium permanganate, $KMnO_4$, 500 mL
0.1 M sodium sulfite, Na_2SO_3
3 M sulfuric acid

CHEMICAL CONCEPT:

Aldehydes are organic compounds that contain a carbonyl group bonded to at least one hydrogen. Their carbonyl group is easily oxidized to a carboxylic acid, which is usually less toxic, less volatile, and more water soluble than the starting aldehydes.

The oxidation is performed using aqueous potassium permanganate. Potassium permanganate is a strong oxidizing agent and the reaction can be followed by monitoring the color change. As the oxidation occurs, the purple permanganate (MnO_4^-) is reduced to a brown manganate dioxide resulting in a loss of purple color. For example:

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

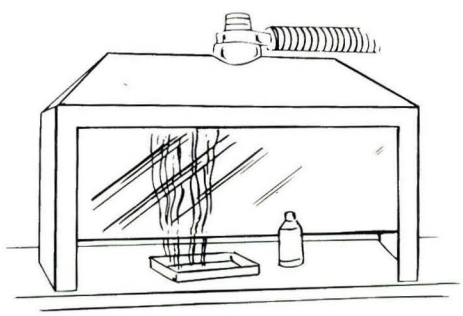
The reaction can be performed in a 1-liter beaker in a hood. The reaction also needs to be heated after the potassium permanganate has been added. Lastly, any excess permanganate must be reduced by sodium sulfite before final disposal of the solution. For glutaraldehyde which contains two aldehyde groups, twice as much permanganate is required.

PROCEDURE A:

1a

Determine the boiling point of the material to be disposed of.



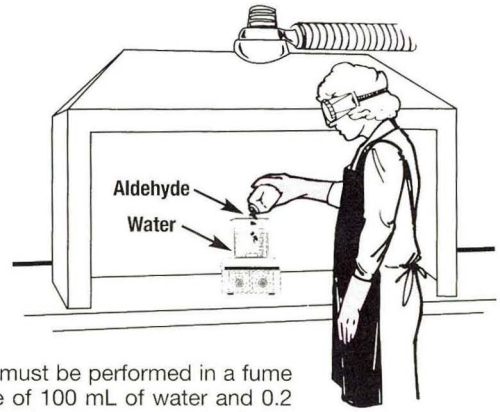


2a

If it is below 105 °C the material may be simply evaporated. Compounds in this group include formaldehyde, formalin solutions, and acetaldehyde. To accomplish the evaporation, place a shallow layer of the material in the large metal pan under an efficient hood, and allow it to evaporate over a period of time.

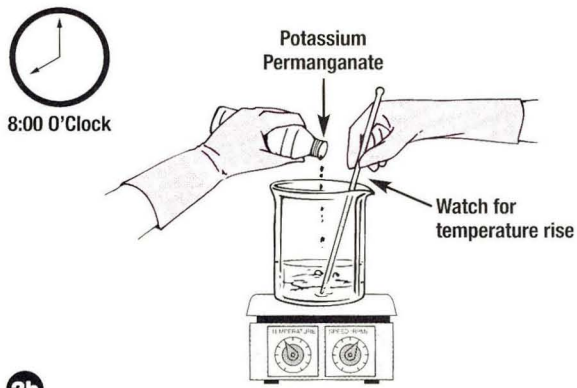
If the material will not readily evaporate, it must be burned. Please refer to Flinn Disposal Method #26c.

PROCEDURE B:



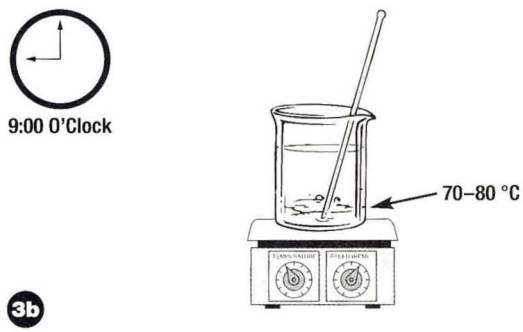
1b

This procedure must be performed in a fume hood. A mixture of 100 mL of water and 0.2 moles of aldehyde is stirred in a 1-L beaker.



2b

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 a temperature is reached that changes the color.



3b

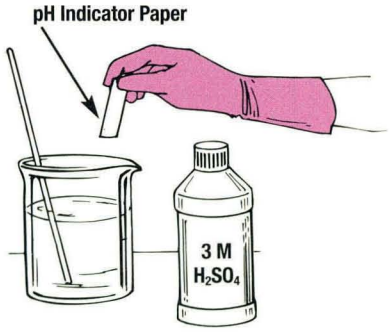
The rest of the permanganate (470 mL) is added slowly at this temperature. The temperature is then raised to 70–80 °C and the mixture stirred for an hour or until the purple color has disappeared, whichever is first.

FLINN METHOD #2 continued on next page.

Please...Read the Narratives

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FLINN METHOD #2 *continued*

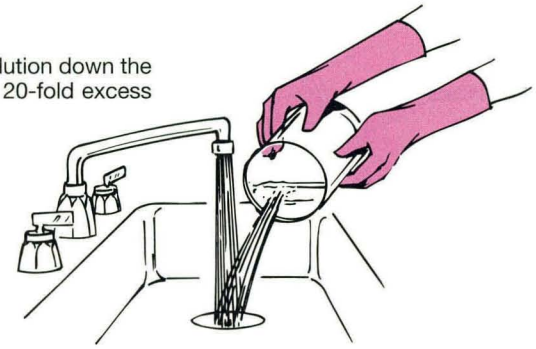


4b

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

5b

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



FLINN METHOD #3 ALKALI METALS AND ALKALINE EARTH METALS

Materials in this class may be reactive with air and with liquids such as water, alcohol, and halogenated hydrocarbons. They should not be allowed to come into contact with wastes containing these liquids. The alkali metals are usually stored in a liquid hydrocarbon 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 best way to dispose of alkali metals is reaction with an alcohol (procedure A) while alkaline metals can be reacted with water or dilute acid (procedure B). All the metals are also destroyed by incineration (see Flinn Disposal Method #26c).

EXAMPLES:

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

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood
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 indicator paper
Ethyl alcohol, anhydrous (for sodium and lithium)
tert-Butyl alcohol (for potassium)
1 M hydrochloric acid

CHEMICAL CONCEPT:

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.

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

During this procedure, hydrogen gas is produced which is an explosion and fire hazard. The reaction also uses ethyl alcohol, an explosion and fire risk. The reaction needs to be carried out in a fume hood, behind a shield, and with proper safeguards.

Anhydrous ethyl alcohol contains very little water and is preferred in this procedure over 95% ethyl alcohol which contains water.

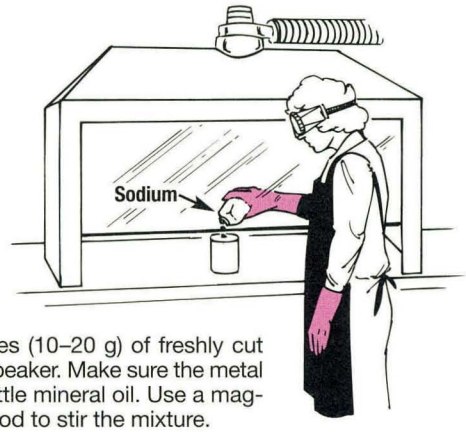
Potassium is the most difficult metal to dispose of safely due to its reactivity and tendency to form explosive peroxides. Even when stored under mineral oil or kerosene, a coating of yellow potassium superoxide (KO_2) is formed, on prolonged storage. Cutting or handling the yellow-coated potassium may result in a violent explosion. Do not attempt to cut yellow-coated potassium. Potassium should not be stored for any extended period of time.

Care must be taken in reacting 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 which auto ignites the flammable alcohol.

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

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

PROCEDURE A: For Sodium and Lithium Metal



1a

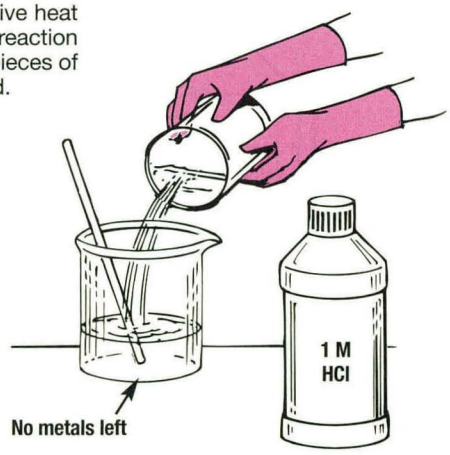
Place several pieces (10–20 g) of freshly cut metal in a 500-mL beaker. Make sure the metal is covered with a little mineral oil. Use a magnetic stirrer or stir rod to stir the mixture.

2a



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 reaction mixture until all the pieces of metal have dissolved.

3a



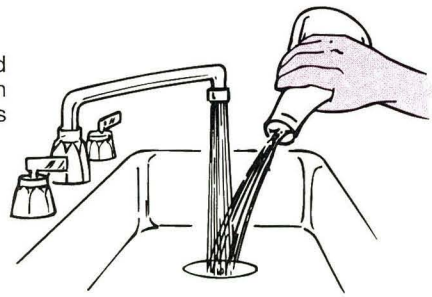
Only after all pieces of metal are gone, slowly add an equal volume of water to the reaction mixture. Neutralize with 1 M hydrochloric acid.

FLINN METHOD #3 continued on next page.

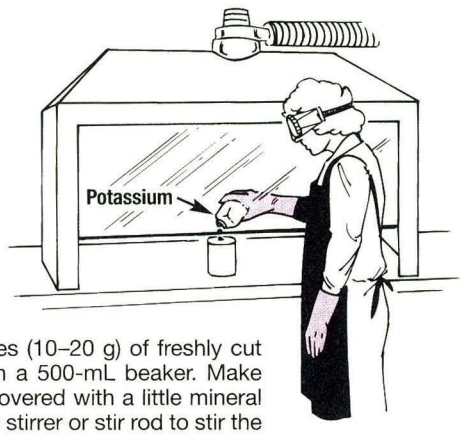
FLINN METHOD #3 *continued*

4a

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



PROCEDURE B: For Potassium Metal



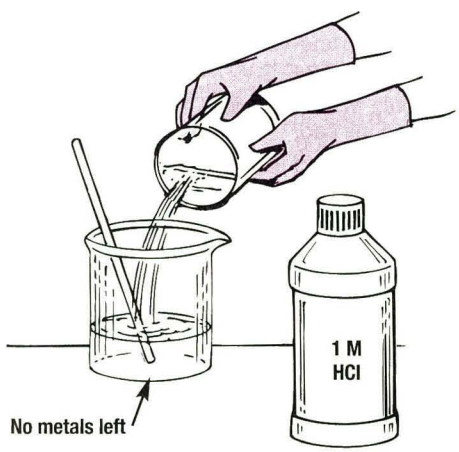
1b

Place several pieces (10–20 g) of freshly cut potassium metal in a 500-mL beaker. Make sure the metal is covered with a little mineral oil. Use a magnetic stirrer or stir rod to stir the mixture.



2b

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. If the reaction is proceeding too slowly, add a few milliliters of dry, anhydrous ethyl alcohol.

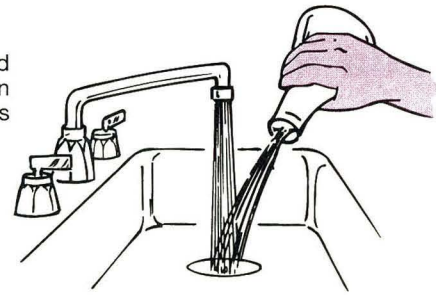


3b

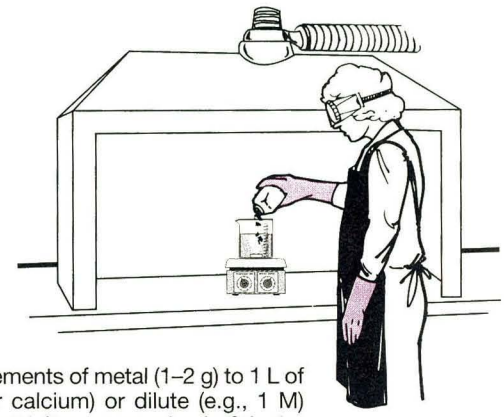
Only after all pieces of potassium are gone, slowly add an equal volume of water to the reaction mixture. Neutralize with 1 M hydrochloric acid.

4b

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

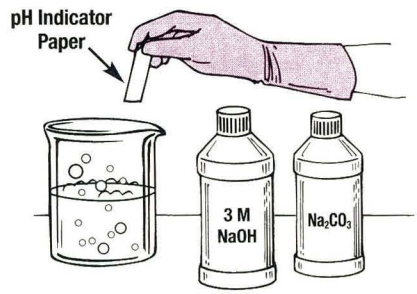


PROCEDURE C: For Calcium and Magnesium Metal



1c

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

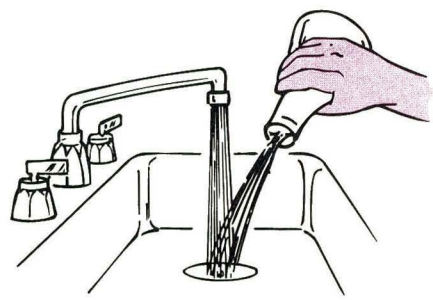


2c

Using pH indicator paper or a monitor, neutralize to pH 7 with 3 M sodium hydroxide or solid sodium carbonate.

3c

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



Please...Read the Narratives

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FLINN METHOD

#4a PICRIC ACID AND RELATED SUBSTANCES

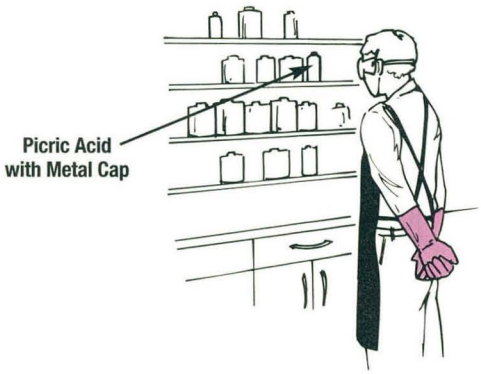
Picric acid cannot be disposed of by untrained personnel. You must contact a commercial waste disposal service, the local bomb squad, or fire department. Chemical destruction of picric acid by sodium sulfide is sometimes recommended, but tends to be incomplete and the resulting residues usually have some explosive properties. Bouin's solution contains picric acid; treat it just as carefully as pure picric acid.

EXAMPLES:
Picric acid, Bouin's solution

MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Glass beaker with about 3 inches of water, large enough to contain picric acid container

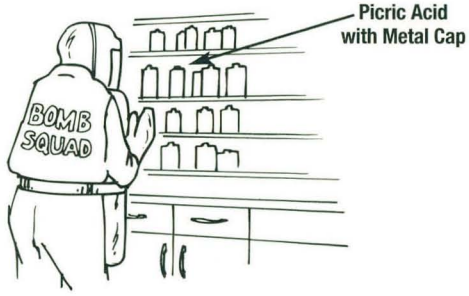
CHEMICAL CONCEPT:
Picric acid is normally sold containing 10–15% water, and in this state it is relatively safe to handle. However, dry picric acid is very explosive. The explosion can be initiated by friction, shock, or sudden heating. Picric acid also reacts with metals to form explosive metal picrates 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:



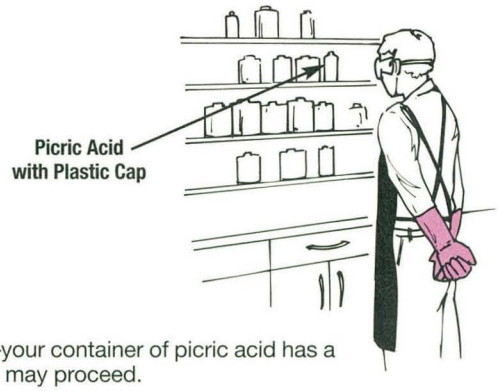
1

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



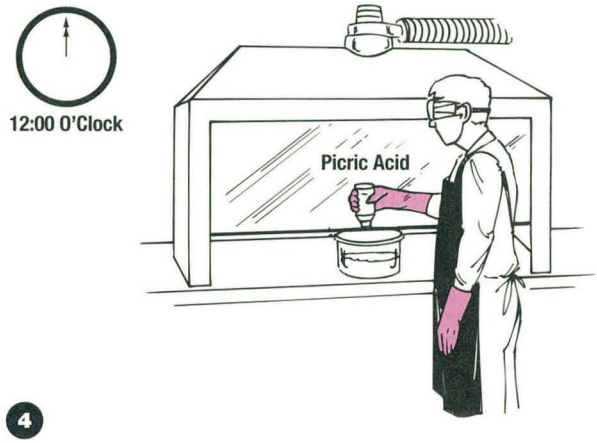
2

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 school 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.)



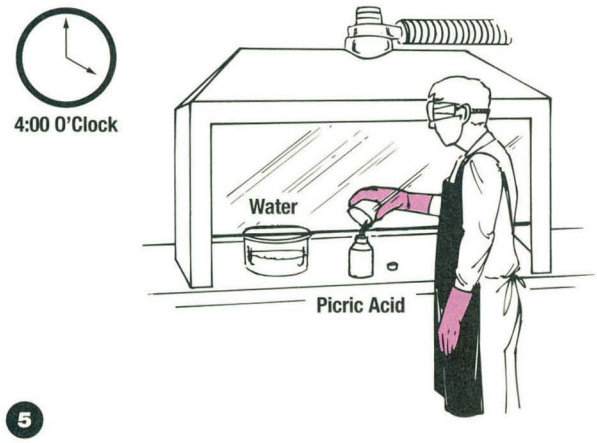
3

If—and only if—your container of picric acid has a plastic cap, you may proceed.



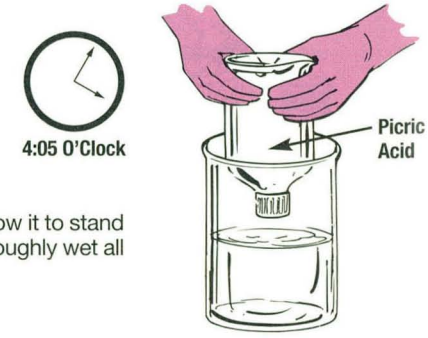
4

Immerse the plastic-capped container upside-down in the beaker of water. Allow it to stand for four hours to permit water to work its way up the threads between the cap and the bottle.



5

Remove the bottle from the beaker. Uncap it. Fill the bottle with water and replace the cap.



6

Re-invert the bottle. Allow it to stand for several days to thoroughly wet all the material inside.

FLINN METHOD #4a continued on next page.

FLINN METHOD #4a *continued*



7

Call a commercial waste disposal service, the local bomb squad, or fire department and have them remove the material from school premises.

FLINN METHOD #4b HALOGENATED HYDROCARBONS

Halogenated hydrocarbons where the halogen is attached directly to an aromatic ring (e.g., benzene) or carbon–carbon double bond are difficult to destroy by chemical means. Halogenated hydrocarbons that contain no carbon–carbon double bonds or have low boiling points can be destroyed using Flinn Disposal Method #27j. The best route for disposal of nonvolatile halogenated hydrocarbons is through incineration. Use either a commercial waste disposal service or Flinn Disposal Method #26c.

EXAMPLES:
Bromobenzene, dichlorobenzene, and perchloroethylene

FLINN METHOD #4c ORGANIC ACIDS, SUBSTITUTED

Substituted organic acids include amino acids and halogenated carboxylic acid (e.g., chloroacetic acid). Amino acids are water soluble and usually have nutritive value. Amino acids are easily disposed of using Flinn Disposal Method #26a or #26b. Most water soluble substituted carboxylic acids and their sodium, potassium, calcium or magnesium salts can be washed down the drain if local regulations permit. See Flinn Disposal Method #26b.

EXAMPLES:
Glycine, methionine

FLINN METHOD #5 AMINES, AROMATIC

Aromatic amines are relatively toxic and flammable materials. Depending on the material, there are several disposal routes. Small quantities of aromatic amines (<500 g) can be disposed of by incineration (see 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 authorities and Flinn Disposal Method #26a.

Three common aromatic amines, pyridine, aniline, and diphenylamine, can be destroyed by oxidation with potassium permanganate.

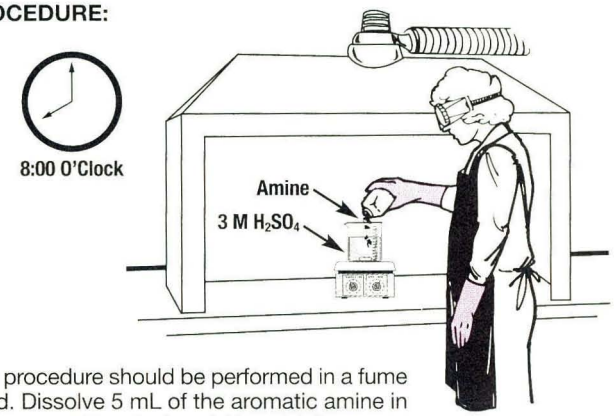
EXAMPLES:
Aniline, pyridine, and diphenylamine

MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles
Fume hood
Magnetic stir plate and stir bar
1-L beaker
pH indicator paper
3 M sulfuric acid
Potassium permanganate
Sodium carbonate or 1 M sodium hydroxide solution
Sodium bisulfite or sodium sulfite

CHEMICAL CONCEPT:
Small amounts of aromatic amines may be oxidized with acidified potassium permanganate. The products of the reaction have not been fully identified but are thought to be nitroso and nitro compounds. These materials are less toxic than the amines and can be flushed down the drain.

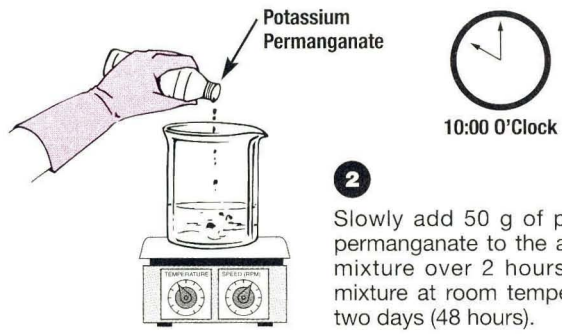
$$C_6H_5NH_3 + KMnO_4 + H^+ \rightarrow C_6H_5NO + C_6H_5NO_2 + \ldots$$

PROCEDURE:



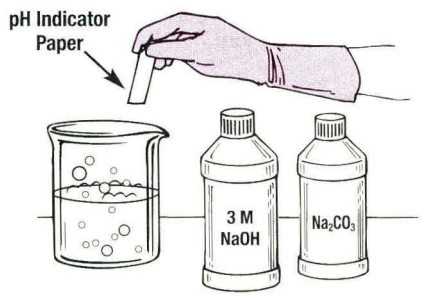
1

This procedure should be performed in a fume hood. Dissolve 5 mL of the aromatic amine in 250 mL of 3 M sulfuric acid in a 1-L beaker.



2

Slowly add 50 g of potassium permanganate to the acid/amine mixture over 2 hours. Stir the mixture at room temperature for two days (48 hours).



3

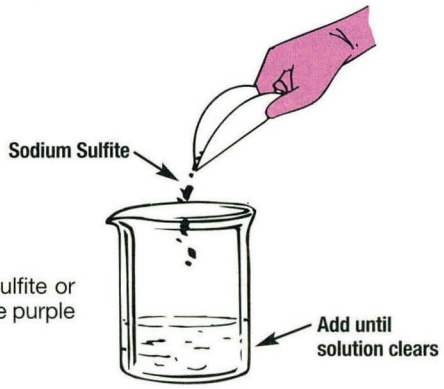
Neutralize the mixture by adding solid sodium carbonate or 1 M sodium hydroxide solution.

FLINN METHOD #5 continued on next page.

Please...Read the Narratives

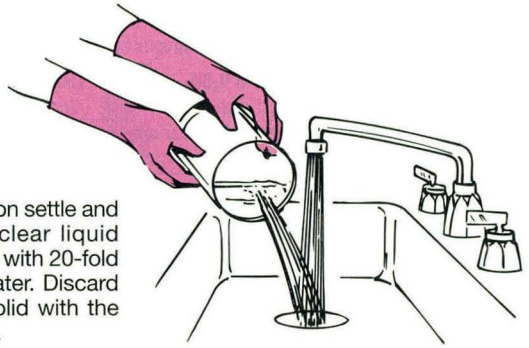
Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures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

FLINN METHOD #5 *continued*



4

Add solid sodium bisulfite or sodium sulfite until the purple color disappears.



5

Let the solution settle and decant the clear liquid into the drain with 20-fold excess of water. Discard the brown solid with the regular trash.

FLINN METHOD #6 SUBSTANCES PRECIPITATED BY CALCIUM ION

Substances in this class are of two different varieties: (a) soluble substances containing the fluoride ion, and (b) soluble substances 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. Hydrofluoric acid is also a poison and insidious in its action on human flesh.

Hydrofluoric acid solutions react with glass and thus can only be treated in plastic containers. However, compounds in this class are all precipitated by calcium ion.

EXAMPLES:

Sodium fluoride, sodium molybdate, sodium tungstate

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood
Calcium hydroxide (slaked lime) in threefold molar excess for HF disposal
1 M calcium chloride solution in threefold molar excess for other disposals
Large plastic beaker or similar container (don't use glass for HF)
Wood stirring stick
3 M hydrochloric acid or 3 M sodium hydroxide as necessary to adjust pH
pH indicator paper
Filtration apparatus

CHEMICAL CONCEPTS:

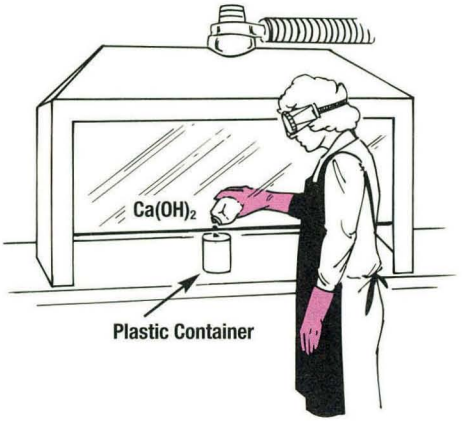
a. For hydrogen fluoride (hydrofluoric acid): By reacting the hydrofluoric acid with calcium hydroxide, two purposes are accomplished simultaneously. The acid is neutralized and the fluoride is converted to the very insoluble calcium salt, which precipitates as a white solid.

$$2HF + Ca(OH)_2 \rightarrow 2H_2O + CaF_2$$

After neutralizing the excess calcium hydroxide with hydrochloric acid, the calcium fluoride is allowed to settle to the bottom of the reaction container. The liquid above contains calcium ion and chloride ion, which are both innocuous. This liquid is referred to as the "supernatant liquid," and merely means the liquid above a solid sitting on the bottom of a container. You really don't have a supernatant liquid until the solid has settled, but rather a suspension of the solid. Thus a supernatant liquid will be clear, not cloudy, and rather than filtering, can be carefully poured off or decanted.

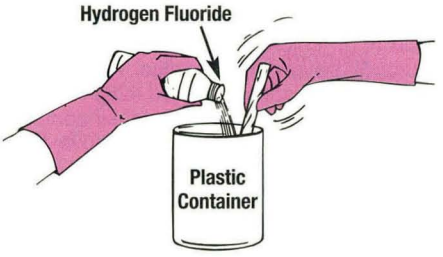
b. The other substances in this class all form insoluble calcium compounds, either calcium fluoride, calcium tungstate or calcium molybdate, with the reaction of the target compound and calcium chloride. These insoluble compounds are judged to be innocuous, and may be sent to a landfill.

PROCEDURE A:
For Hydrogen Fluoride (Hydrofluoric Acid) Disposal



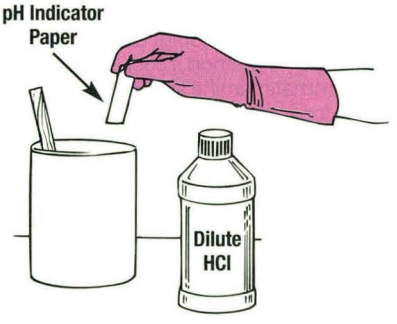
1a

Place a threefold molar excess of solid calcium hydroxide in a plastic container, and fill it half-full of water. The calcium hydroxide will only slightly dissolve.



2a

Use a fume hood. Slowly add the hydrogen fluoride solution to this suspension, with constant stirring. Considerable heat may be evolved.

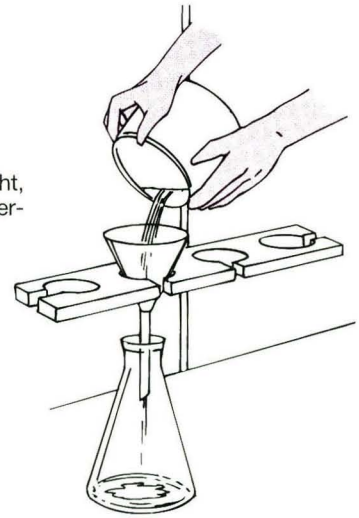


3a

When the addition is complete, check the pH of the resulting mixture with pH indicator paper. Neutralize the mixture to pH 7 with dilute hydrochloric acid. This will dissolve most of the excess calcium hydroxide. Do not make the solution acidic, as this will increase the solubility of the calcium fluoride just precipitated.

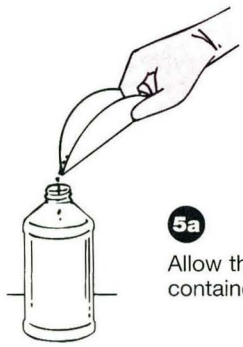
FLINN METHOD #6 continued on next page.

FLINN METHOD #6 *continued*



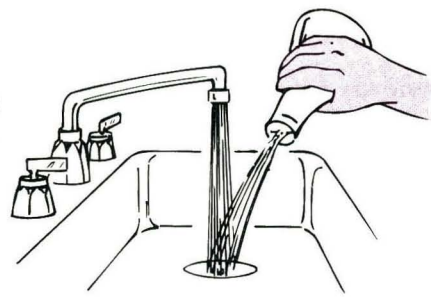
4a

Let the suspension sit overnight, then filter or decant off the supernatant liquid.



5a

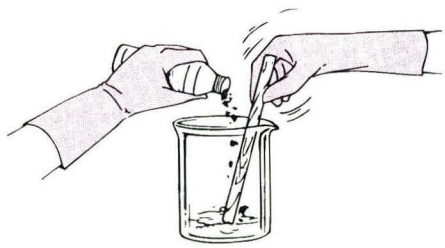
Allow the solid to dry, then place it in a plastic container, and send it to a landfill.



6a

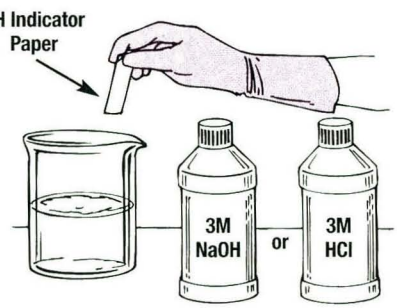
Flush the supernatant liquid down the drain with excess water.

PROCEDURE B:



1b

For disposal of the other compounds in this class: dissolve the compound in the smallest amount of water possible.



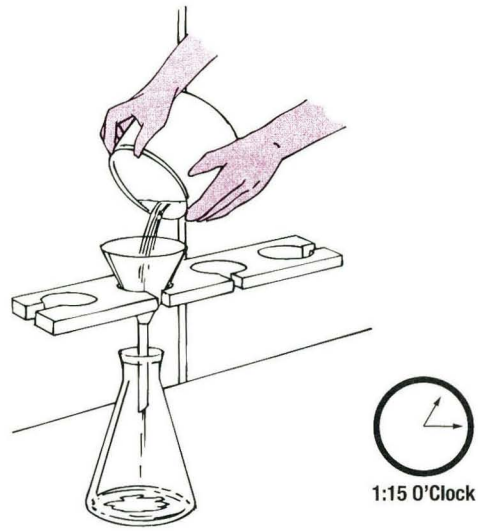
2b

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



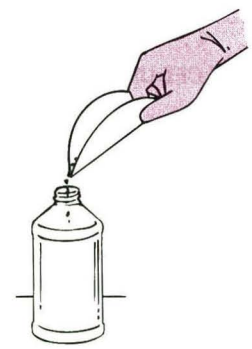
3b

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.



4b

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



5b

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

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. These procedures may be dangerous. Once again...read the narratives that precede these specific chemical disposal methods.

FLINN METHOD

#8 AZIDES AND AZO- COMPOUNDS

Azides should NOT be drain-disposed. Drain disposal not only contaminates sewer water, but azides can also react with lead and copper in drain lines, solder joints and brass fittings. These metal azides remain resident in the sewer system, and are unstable and explosive. Drain systems have been destroyed by such explosions. In addition, azides are not biodegradable and kill the necessary bacteria present in the digestion system of wastewater treatment plants. Stocks of these materials should be kept low. Note that the order of addition, nitrite before acid, is important; if the order is reversed, acidifying before adding the nitrite, the result will be the evolution of extremely poisonous HN_3, hydrazoic acid.

EXAMPLES:

Sodium azide, triphenyl tetrazolium chloride

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood
Magnetic stirrer and stir bar or glass stirring rod
3 M sodium nitrite solution, in a 50% molar excess
3 M sulfuric acid
Large glass beaker
pH indicator paper
Potassium iodide-starch test paper

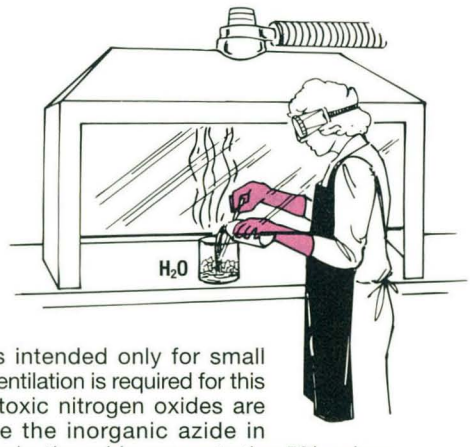
CHEMICAL CONCEPT:

The azide ion reacts with the nitrite ion in the presence of acid to form nitrous oxide, nitrogen and water:

$$4N_3^- + 2NO_2^- + 6H^+ \rightarrow 6N_2 + N_2O + 3H_2O$$

Nitrous oxide is poisonous in large quantities. (Nitrous oxide is also known as laughing gas, and in small quantities is a general anesthetic.) The reaction proceeds best in a weakly acidic solution, but is still slow. The azide ion is a strong reducing agent, and will preferentially react with the nitrite ion. Only when azide is consumed will iodide ion from the potassium iodide-starch test paper be oxidized by the nitrite ion to iodine. The iodine produced will form the familiar blue complex with starch. Thus, the presence of blue color on the potassium iodide-starch test paper indicates that all the azide has been consumed.

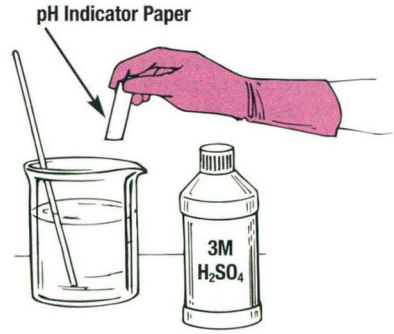
PROCEDURE:



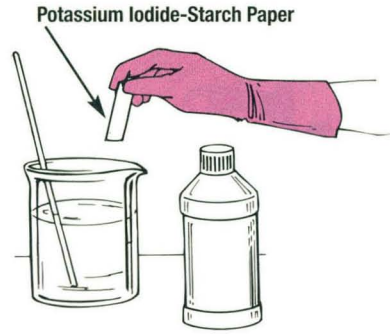
1. This procedure is intended only for small quantities. Good ventilation is required for this procedure since toxic nitrogen oxides are evolved. Dissolve the inorganic azide in enough water to make the azide concentration 5% or less.



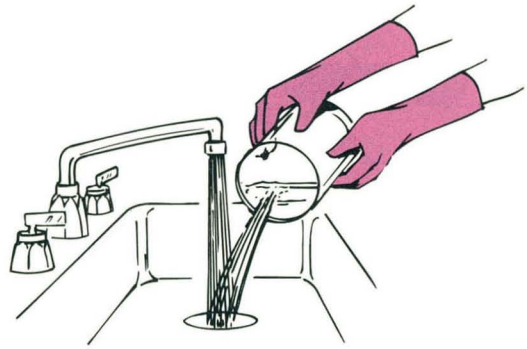
2. Slowly add 3 M sodium nitrite solution, while stirring, until there is a 50% molar excess over the amount of azide.



3. Slowly, and with continuous stirring, acidify the solution with 3 M sulfuric acid, checking with indicator paper as you add. The pH should not go below 5.

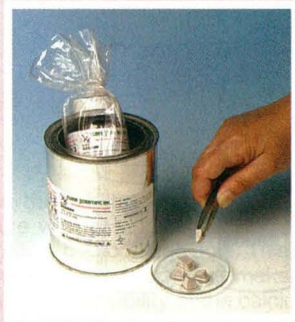


4. Allow the mixture to stand, periodically checking with potassium iodide-starch paper. The decomposition is complete when the potassium iodide-starch paper turns blue.



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

No Disposal Required!



Flinn sodium is packaged ready-to-use and ready-to-store. Five small pieces of sodium (0.3–0.5 g each), perfect for demonstrations, are packaged under mineral oil in a PVC-coated glass bottle, in a plastic bag and then a metal can for safer storage.

Count on Flinn for smaller package sizes to eliminate disposal problems.

FLINN METHOD

#9 CARBON DISULFIDE

Carbon disulfide is a highly volatile, highly toxic, and flammable solvent. Extreme care should be taken when handling and disposing of this material. Large quantities should be incinerated (see Flinn Disposal Method #26c). Smaller quantities may be evaporated or reacted with bleach to form sulfuric acid.

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood or outdoor site
Dry chemical (ABC) fire extinguisher
Iron or glass pan (procedure A)

For Procedure B

Large bucket or similar container
Laundry bleach or calcium hypochlorite
Thermometer
Magnetic stirrer and stir bar or stirring rod

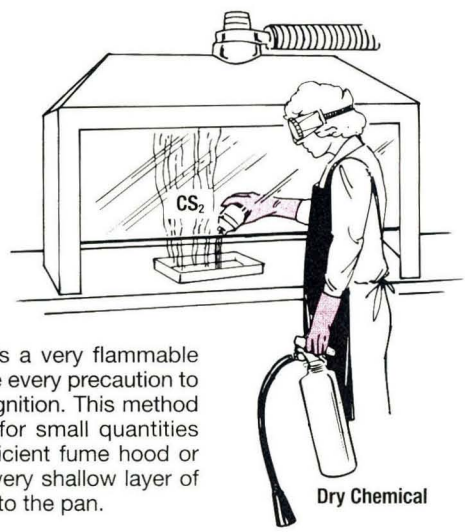
CHEMICAL CONCEPT:

Bleach (sodium hypochlorite) is a strong oxidizing agent and will oxidize carbon disulfide to carbon dioxide and sulfuric acid.

$$CS_2 + 8OCl^- + H_2O \rightarrow CO_2 + 2H_2SO_4 + 8Cl^-$$

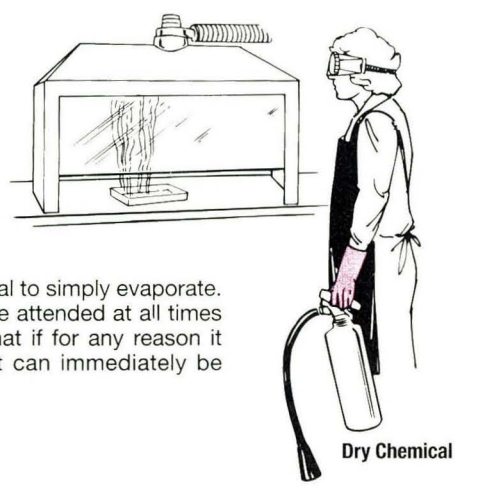
For each 0.5 mole (38 g, 30 mL) of carbon disulfide, 5 moles (25% excess) hypochlorite is required. Laundry bleach (7 L) or calcium hypochlorite (550 g $Ca(OCl)_2$ in 2.5L of water) solution are suitable sources of hypochlorite. The reaction temperature must be maintained between 20–30 °C to avoid evaporation of the carbon disulfide.

PROCEDURE A:



1a

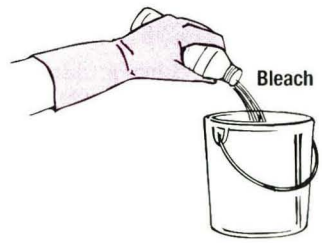
Carbon disulfide is a very flammable substance, so take every precaution to avoid sources of ignition. This method is recommended for small quantities only. Under an efficient fume hood or outdoors, pour a very shallow layer of carbon disulfide into the pan.



2a

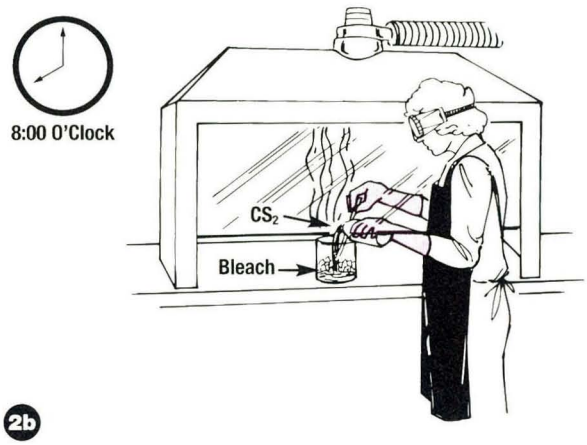
Allow the material to simply evaporate. The pan must be attended at all times to make sure that if for any reason it should ignite, it can immediately be extinguished.

PROCEDURE B:



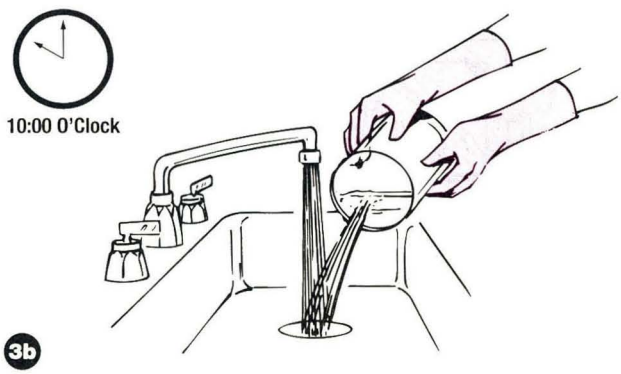
1b

Work in a hood. Add 7 L of laundry bleach or a calcium hypochlorite solution [550 g $Ca(OCl)_2$ in 2.5 L of water] to a large bucket or container.



2b

Slowly add 30 mL (0.5 M) of carbon disulfide so that the reaction temperature is maintained between 20–30 °C.



3b

When addition is complete, continue to stir for two hours or until a clear, homogeneous solution remains. The reaction mixture may be flushed down the drain with excess water.

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FLINN METHOD

#10 BASES, STRONG AND WEAK, AND BASIC ANHYDRIDES

Neutralizing acid and base solutions are very common disposal procedures and should present minimal problems. 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 should be near neutral (pH 5–9) before discharge to the drain. In this procedure, bases are neutralized with dilute hydrochloric acid.

EXAMPLES:
Ammonium hydroxide, calcium oxide, sodium hydroxide

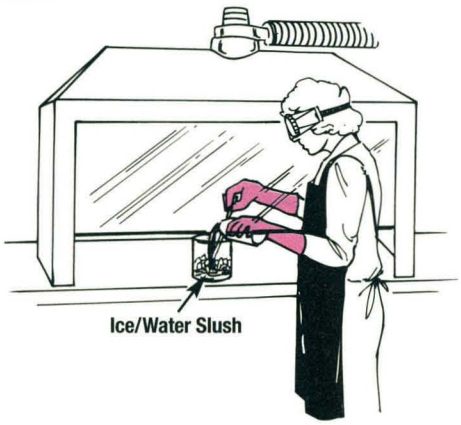
MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood, if disposing of aqueous ammonia solution
Large glass beaker
Glass stirring rod
Ice/water slush (optional)
3 M hydrochloric acid
pH indicator paper

CHEMICAL CONCEPT:
All bases react with acids in aqueous solution to form a salt and water. Basic anhydrides react with water to form bases, which are then neutralized with acid.

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

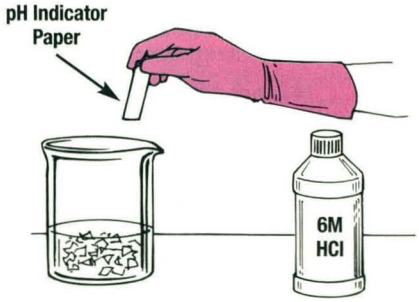
The soluble salts formed are innocuous, and can be flushed down the drain with water.

PROCEDURE:



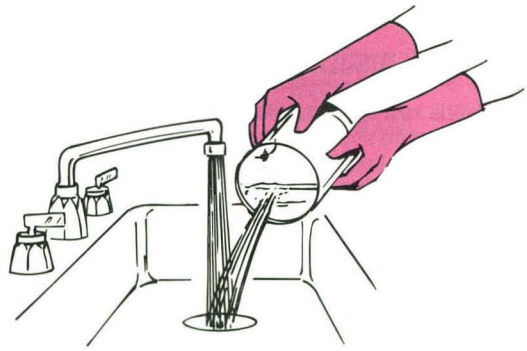
1

Prepare a dilute solution of (1 M or <10%) base by diluting the solution or dissolving the solid into water. Considerable heat may be involved when dissolving a solid base. It is wise to experiment with a small quantity to determine the heat generated, and if an ice/water slush is required.



2

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.



3

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

FLINN METHOD

#11 SILVER COMPOUNDS

Silver and silver compounds are expensive but often can be reclaimed for later use. Below, we present a silver recovery process.

EXAMPLES:
Silver nitrate, silver chloride, silver oxide

MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Large glass beaker
Glass stirring rod
1 M sodium chloride, NaCl
Nitric acid, HNO_3, conc.
6 M sodium hydroxide, NaOH
Sucrose
2 M sodium hydroxide
Filtration apparatus
Magnetic stirrer/hot plate with stir bar

CHEMICAL CONCEPT:
(Silver recovery process)
The first step (dissolving in nitric acid), puts the metals into solution as metal ions. The next step of adding sodium chloride causes the formation of a precipitate which is silver chloride. Since all metals (except platinum and gold) will dissolve in nitric acid, then any other metals present (in addition to silver) will also precipitate, e.g., lead as lead chloride. If your silver is still relatively pure and you wish to prepare AgCl, you want to stop after this step (step 2a).

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

To produce silver metal, the silver chloride is dissolved in a strong base (NaOH) and heated. Sucrose is then added to this mixture. The disaccharide sucrose will hydrolyze in a strong base to the monosaccharides fructose and glucose. Fructose is an alpha-hydroxy ketose; glucose is an aldose. Both of these substances, i.e., fructose and glucose will reduce silver ion to silver metal. Silver will be formed as a heavy gray precipitate.

The last step has the precipitate being redissolved in nitric acid. Silver oxide is precipitated upon addition of sodium hydroxide. The substance should be quite pure since other cations and anions would have stayed in solution during the prior processes.

(Disposal method)
The silver is precipitated as silver chloride, using cheap sodium chloride. Although silver chloride is not as insoluble as silver sulfide, it is insoluble enough so that any silver ion that may leach from silver chloride in a landfill will be of such small concentration as to produce no hazard, and would probably react to form silver oxide in any case.

FLINN METHOD #11 continued on next page.

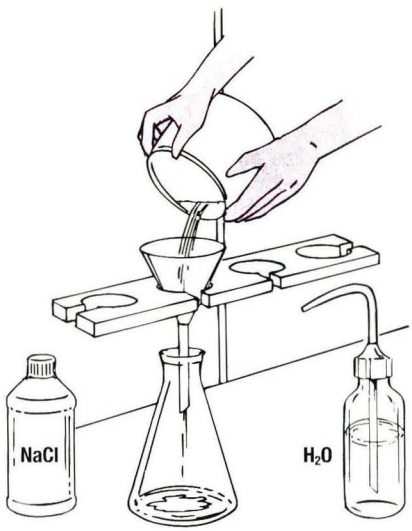
FLINN METHOD #11 *continued*

PROCEDURE A:
A Silver Recovery Process Presented as a "Recipe"

1a

Dissolve the silver wastes in as little nitric acid as possible. For about 100 g of silver, use 60–70 mL of concentrated (15–16 M) nitric acid.



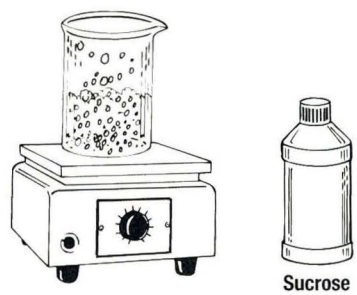


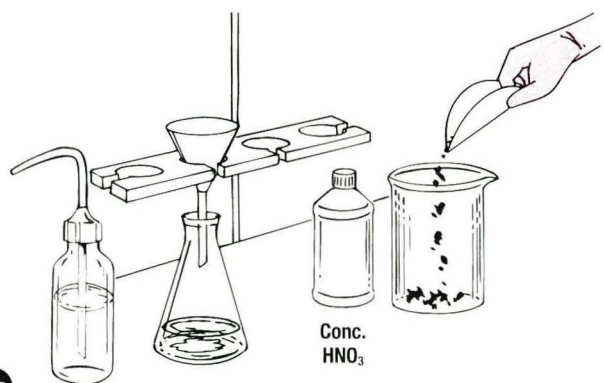
2a

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.)

3a

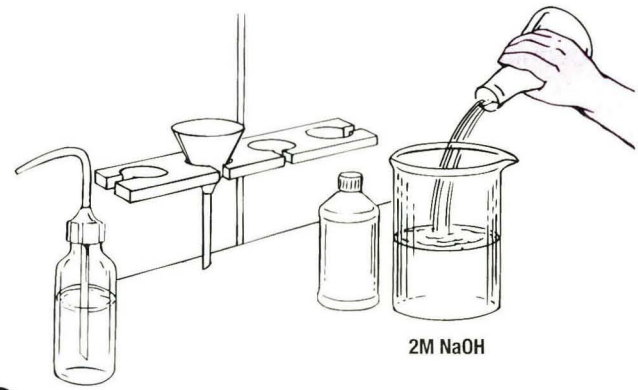
Suspend the AgCl in 6 M NaOH (for 100 g of Ag, use about 500 mL of NaOH), and boil it for about 30 minutes, during which time add sucrose (about 250 g or 1 cup per 100 g of Ag) in small amounts at frequent intervals. Stirring is not necessary, only occasional swirling. At first there is considerable frothing, and then the solution becomes dark brown. Finally a heavy, gray precipitate forms.





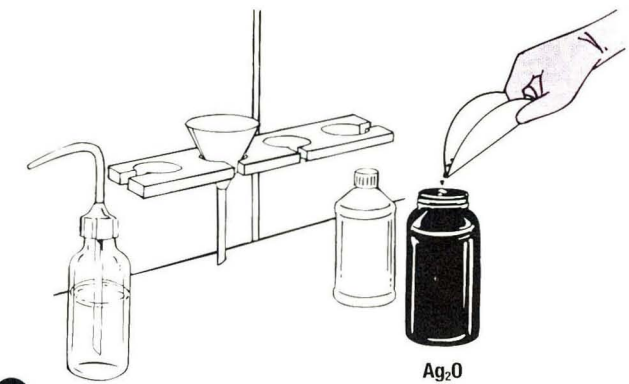
4a

Filter and wash this precipitate, then dissolve the precipitate in as little nitric acid as possible. For about 100 g of Ag, use 60–70 mL of concentrated HNO_3.



5a

Filter and pour the filtrate into 2 M NaOH to precipitate brown Ag_2O. (For 100 g of Ag, use about 500 mL of 2 M NaOH.)

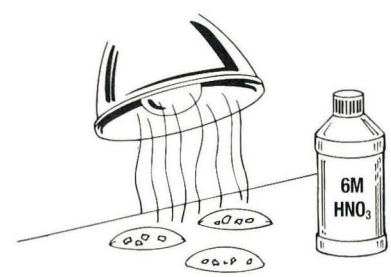


6a

Filter, wash, dry, and store the Ag_2O. It can be converted to silver nitrate or silver chloride at a later date.

7a

If you would like to convert the silver oxide to silver nitrate, dissolve the silver oxide in 6 M HNO_3 and dry the product on either a steam mantle or under heat lamps.



If you wish to convert the silver oxide to silver chloride dissolve the silver oxide in 6 M HNO_3, add 10% molar excess of sodium chloride. Collect the filtrate, wash with water and dry.

This process requires the use of quite a bit of nitric acid and sodium hydroxide. It is nevertheless a relatively simple process and surely a money saver. If you do not wish to attempt the above reclamation procedure, you may dispose of soluble silver compounds by the next procedure.

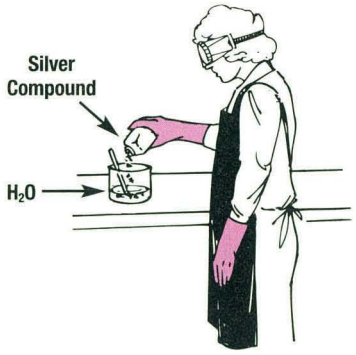
FLINN METHOD #11 continued on next page.

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FLINN METHOD #11 *continued*

PROCEDURE B: Disposal Method

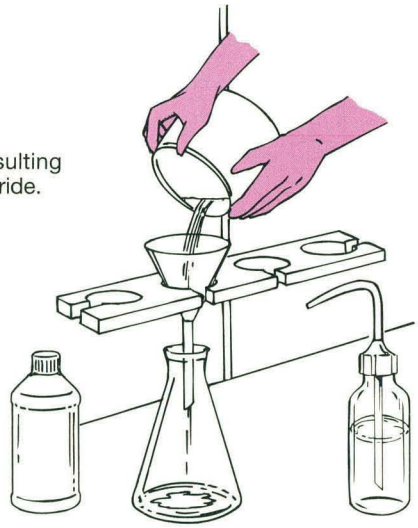


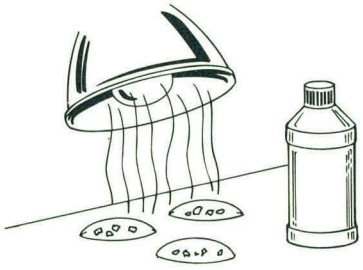
1b Dissolve the silver salt in water in the beaker.



2b Add a 50% molar excess of sodium chloride solution and stir for complete mixing.

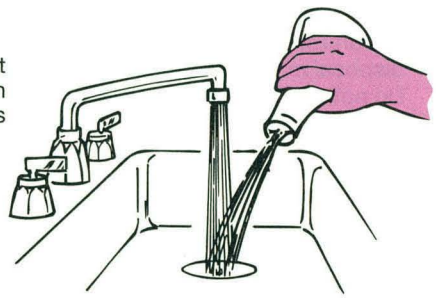
3b Decant or filter the resulting precipitate of silver chloride.





4b Allow the precipitate to dry and dispose of it in a landfill approved for such wastes.

5b Flush the supernatant liquid down the drain with a 20-fold excess of water.



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 thrown away with general refuse as they may cause fires or form explosive mixtures.

EXAMPLES:

Bromine, iodine, sodium chlorate, potassium permanganate, sodium chromate

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
50% aqueous solution of sodium thiosulfate, $Na_2S_2O_3$ (hypo)
3 M sulfuric acid
Large glass beaker
Glass stirring rod
pH indicator paper
1 M sodium hydroxide solution

CHEMICAL CONCEPT:

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. Thus oxygen, as an oxidizing agent, reacts with carbon to produce carbon dioxide.

$$C + O_2 \rightarrow CO_2$$

The example above is a chemical representation of the burning of charcoal.

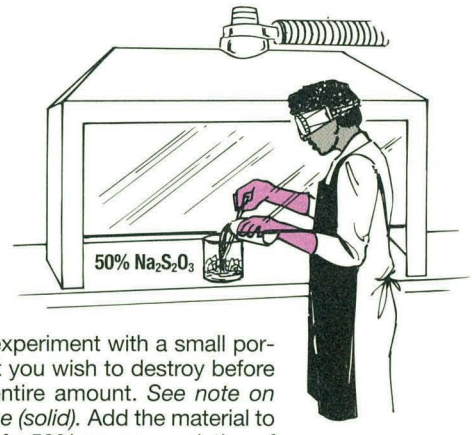
The oxidation state of both carbon and oxygen in their elemental form is zero. When the reaction is complete, the carbon has been oxidized from zero to plus 4 (+4), while the oxygen has been reduced from zero to negative 2 (–2). The complementary processes of oxidation and reduction are often accompanied by the evolution of considerable heat.

It is for this reason that we recommend that oxidizing agents be chemically changed before disposal, so that there is no possibility of a discarded oxidizing agent inadvertently reacting at some later time with some chemically combustible material and producing a lot of heat, which could lead to combustion. (This is why you don't store oily rags; under some conditions these rags, and their associated oil, can undergo oxidation from oxygen in the air, heat up and burst into flames).

We recommend that oxidizing agents be safely reacted with a substance that is inexpensive and will destroy the oxidizing power before disposal. Such a substance is sodium thiosulfate. This reaction proceeds best in weakly acidic solutions. (Too much acid will react with the sodium thiosulfate directly, precipitating elemental sulfur from the mixture.) In the example below, the thiosulfate ion reacts with the bromate ion to produce innocuous sulfate ion and bromide ion. Any excess acid is neutralized with base before flushing down the drain.

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

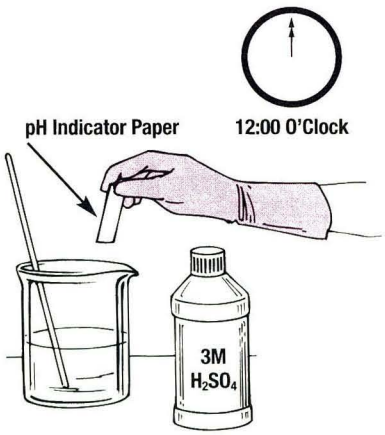
PROCEDURE:



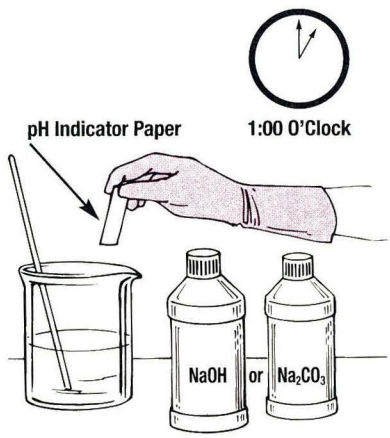
1 This method is for small quantities of laboratory oxidizing agents only. It is best to experiment with a small portion of the amount you wish to destroy before undertaking the entire amount. *See note on next page for iodine (solid).* Add the material to a twofold excess of a 50% aqueous solution of sodium thiosulfate (hypo) with continuous stirring.

FLINN METHOD #12a continued on next page.

FLINN METHOD #12a *continued*



2 Add 3 molar sulfuric acid while stirring to bring the pH in the range of 2–3. Check with indicator paper. A temperature rise indicates the reaction is proceeding. Add more 3 molar sulfuric acid as necessary to produce such a rise. Allow the mixture to stand for about one hour.

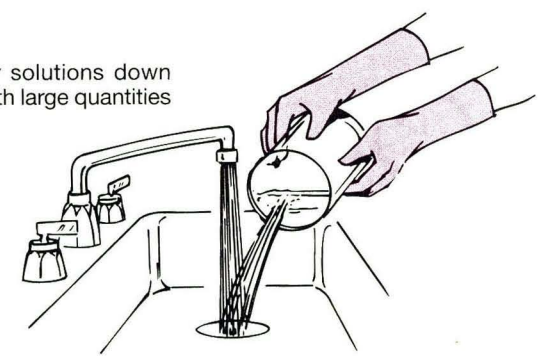


3 Again check with pH paper. Neutralize the solution with either sodium hydroxide solution or sodium carbonate solution.

4 The residues from the above procedure must undergo further treatment if they contain chromium or manganese. The products from the reduction of chromates, dichromates, and permanganates are insoluble manganese dioxide or chromium hydroxide. These materials can be removed by filtration and must be treated by Flinn Disposal Method #27f before final disposal. Do not dump chromium salts down the drain.



5 Flush other solutions down the drain with large quantities of water.



Note: When disposing of solid iodine, which is only slightly soluble in water, place the iodine crystals in the 50% aqueous solution of sodium thiosulfate, but skip the step of adding sulfuric acid. Rather, add a small amount of sodium carbonate (1 g) and stir until the iodine is consumed. Then check with pH paper, and go ahead with the remainder of the procedure.

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 reducing agents safe for disposal.

EXAMPLES:

Potassium nitrite, sodium sulfite, sodium thiosulfate

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Sodium carbonate, Na_2CO_3
Sodium hypochlorite solution (bleach)
Ammonium hydroxide, NH_4OH (proc. B)
3 M hydrochloric acid, HCl (proc. B)
Large glass beaker
Glass stirring rod
pH indicator paper
1 M sodium hydroxide solution
1 M hydrochloric acid

CHEMICAL CONCEPT:

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. (See the discussion on oxidizing agents under Chemical Concept in Flinn Disposal Method #12a 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.

We recommend that reducing agents be safely reacted with a substance that will destroy the reducing power before they are disposed of. One such substance is bleach or sodium hypochlorite. This works best in a weakly basic solution, and a cheap base is sodium carbonate. So first, 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 which contains innocuous ions is flushed down the drain. In the example below, sulfite ion reacts with hypochlorite ion to produce sulfate and chloride ions, all in aqueous solution.

$$SO_3^{-2} + ClO^- \rightarrow SO_4^{-2} + Cl^-$$

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.

$$HNO_2 + NH_4^+ \rightarrow N_2 + 2H_2O + H^+$$

Note: The astute teacher may realize from the above discussions of oxidizing and reducing agents that the way to dispose of these substances is to react a substance from one class with a substance from another class. Think through the chemistry, and if you feel comfortable with it, try this "shortcut" of two processes compressed into one. You will also save costs of the other chemicals required. Always use small quantities when trying a new reaction, and be sure you know what products you will get and any potential hazards associated with them.

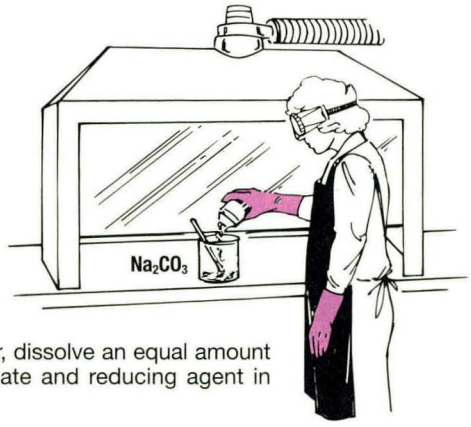
FLINN METHOD #12b continued on next page.

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. These procedures may be dangerous. Once again...read the narratives that precede these specific chemical disposal methods.

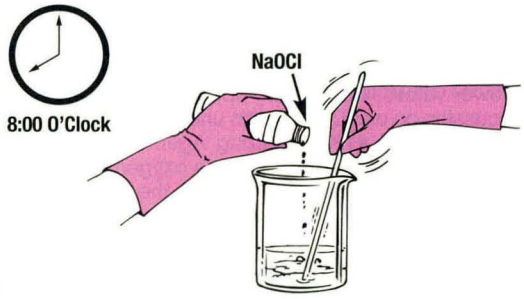
FLINN METHOD #12b *continued*

PROCEDURE A: Sulfites, Thiosulfates



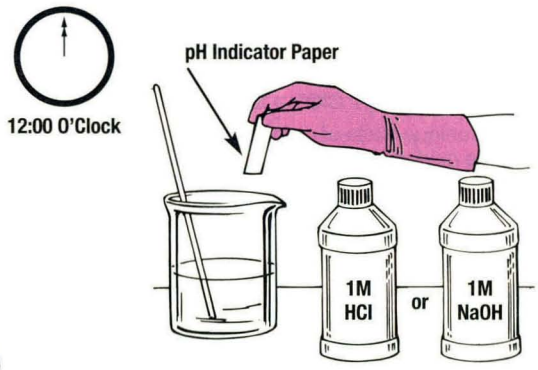
1a

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



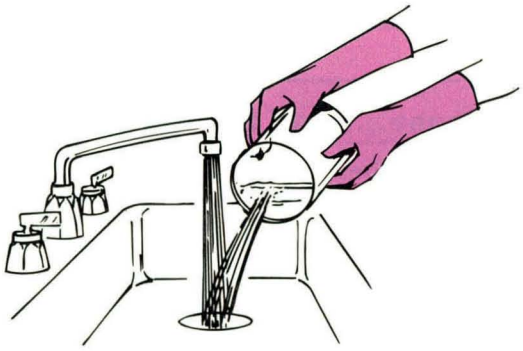
2a

Slowly add a 25% molar excess of bleach to this mixture, with continuous stirring. The reaction may be vigorous and produce heat, so use caution. Allow the completed mixture to stand for several hours.



3a

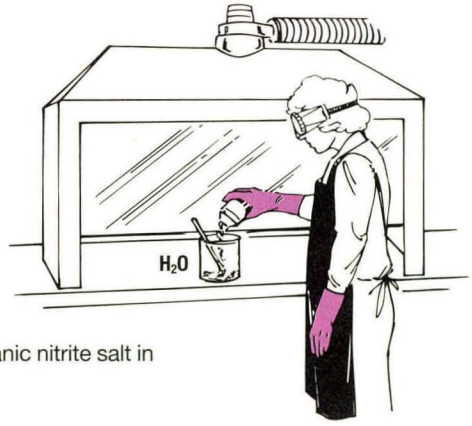
Check the mixture with pH indicator paper and neutralize as necessary. Use sodium hydroxide solution if acidic, or hydrochloric acid solution if basic.



4a

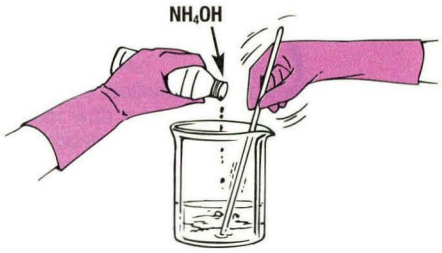
Flush the neutral solution down the drain with a 20-fold excess of water.

PROCEDURE B: Nitrites



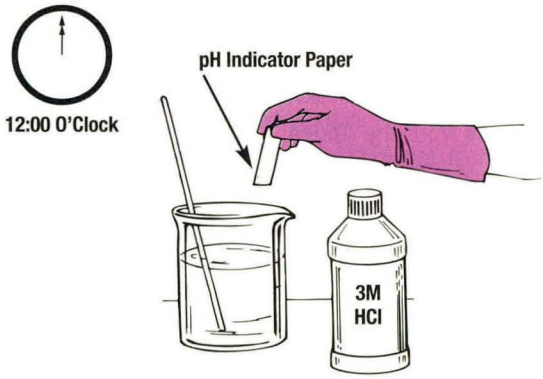
1b

Dissolve the inorganic nitrite salt in distilled water.



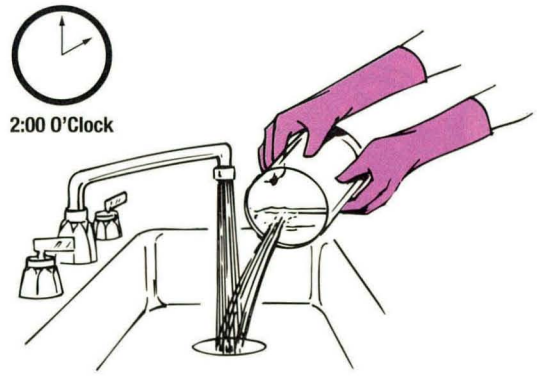
2b

Add 50% molar excess ammonium hydroxide solution.



3b

Using pH indicator paper to measure, acidify the solution to pH 1 with 3 M hydrochloric acid. Stir for two hours.



4b

Check the pH of the solution, neutralize if necessary. Wash the solution down the drain with excess water.

FLINN METHOD

#13 ORGANIC SULFIDES, MERCAPTANS AND THIOAMIDES

Many organic sulfides and mercaptans are very toxic and should not be drain disposed. They are easily destroyed by incineration (see Flinn Disposal Method #26c) or oxidation with sodium hypochlorite.

EXAMPLES:
Thioacetamide, thiourea, phenyl thiocarbamide

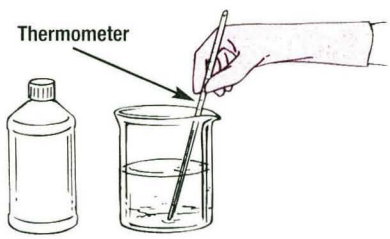
MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood
5% sodium hypochlorite solution; this is regular household bleach
Large glass beaker
Glass stirring rod
Thermometer

CHEMICAL CONCEPT:
Organic sulfides, thioamides, and mercaptans are oxidized by sodium hypochlorite to a mixture of nonhazardous and water soluble sulfonates, nitrates, and carbonates.

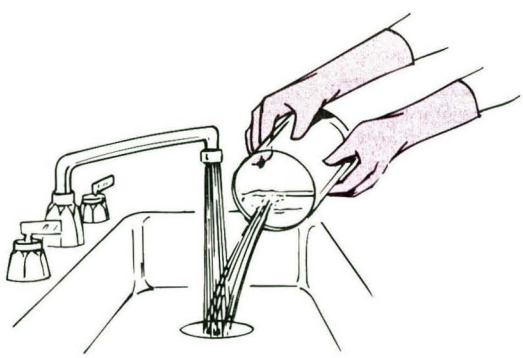
PROCEDURE:



1. Place a volume of sodium hypochlorite solution appropriate to the amount of material disposed of in the large beaker (about 100 mL of bleach per g of material).



2. Add the mercaptan or sulfide slowly while stirring. The reaction usually starts quickly, as evidenced by a temperature rise and disappearance of the mercaptan. Maintain the temperature at about 50 °C by varying the addition rate as necessary. When the addition is complete (it may take an hour), allow the mixture to come to room temperature and stand overnight.



3. Flush the neutral material down the drain with a 20-fold excess of water.

FLINN METHOD

#14 CYANIDES

We urge you to consider having all cyanides removed by waste disposal professionals. Cyanides are severe and rapid-acting poisons, being quickly absorbed into the body via the respiratory system, skin, eyes and mouth. The cyano-complexes of iron are less hazardous. This method is applicable only to cyanides and cyano-complexes Flinn sells, and for small quantities, 100 g or less.

EXAMPLES:
Potassium cyanide, potassium ferrocyanide

MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood
Large glass beaker
Glass stirring rod
3 M sodium hydroxide solution (twofold molar excess)
pH indicator paper
Ice bath (optional)
Sodium hypochlorite solution (bleach)
30% calcium hypochlorite solution

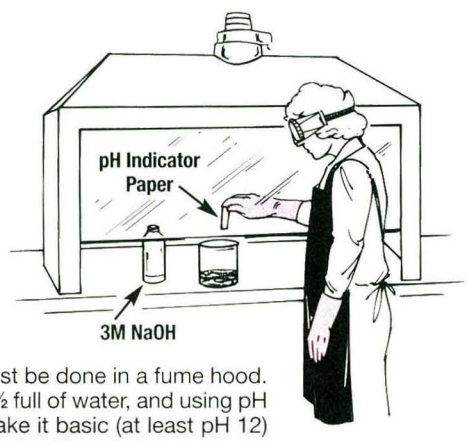
CHEMICAL CONCEPT:
Inorganic cyanides (e.g., KCN, NaCN) readily dissolve in water to give free cyanide ions. Reaction with an acid will produce highly toxic hydrogen cyanide gas. Free cyanide ions are complexed or oxidized. For small quantities of dilute cyanides, the addition of ferrous sulfate will complex the cyanide and produce a ferrocyanide complex. Ferro and ferricyanides are much less toxic and volatile than cyanide salts.

Both free cyanide and complex cyanides 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. If larger quantities of cyanides are being destroyed, a 30% calcium hypochlorite solution is more efficient.

PROCEDURE:



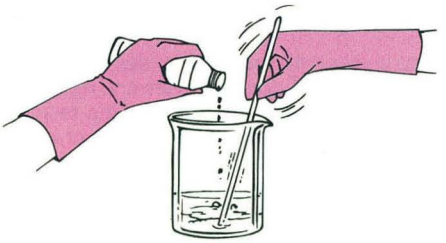
1. This procedure must be done in a fume hood. Fill a large beaker ½ full of water, and using pH indicator paper, make it basic (at least pH 12) with 3 M sodium hydroxide solution.

FLINN METHOD #14 continued on next page.

Please...Read the Narratives

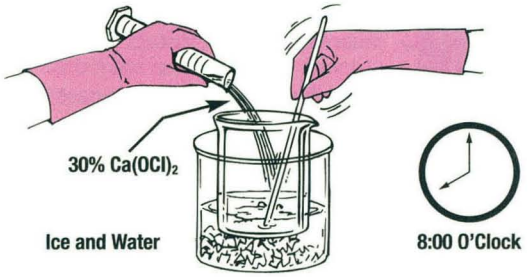
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FLINN METHOD #14 *continued*



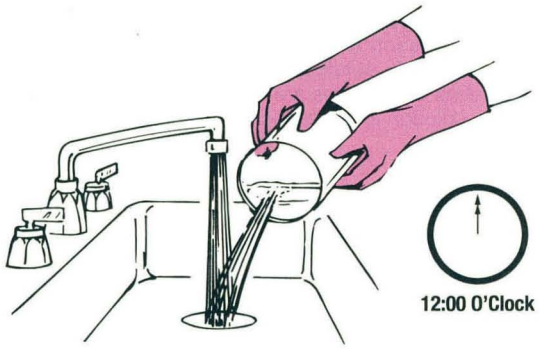
2

Dissolve the cyanide or cyano-complex in the water.



3

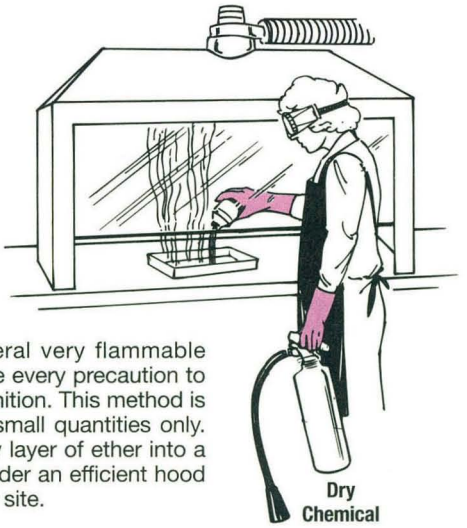
While stirring, slowly add the sodium hypochlorite solution (about 100 mL per g CN) or 30% calcium hypochlorite solution (20 mL per g CN). Heat may be evolved; maintain the temperature below 50 °C by using an ice bath if necessary. Once the addition of hypochlorite is completed (use a twofold molar excess), allow the mixture to stand for several hours.



4

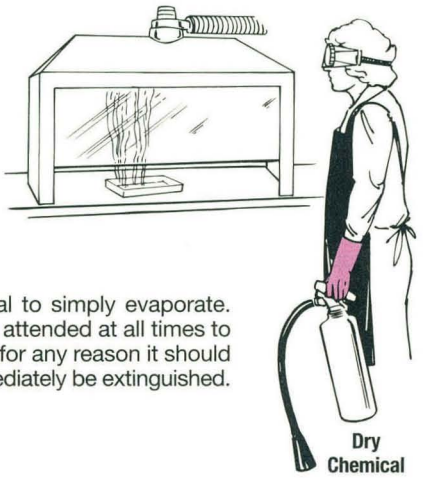
Flush the mixture down the drain with a 20-fold excess of water.

PROCEDURE:



1

Ethers are in general very flammable substances, so take every precaution to avoid sources of ignition. This method is recommended for small quantities only. Pour a very shallow layer of ether into a pan and place it under an efficient hood or in a safe outdoor site.



2

Allow the material to simply evaporate. The pan must be attended at all times to make sure that if for any reason it should ignite, it can immediately be extinguished.

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 should not be opened and should be disposed of by the appropriate authorities.

EXAMPLES:

Diethyl ether, dioxane, tetrahydrofuran

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood or outdoor site
Dry chemical (ABC) fire extinguisher
Iron or glass pan

CHEMICAL CONCEPT:

No concept statement judged necessary for this procedure.

FLINN METHOD #16 HYDRAZINES AND THEIR SALTS

Hydrazines contain a nitrogen–nitrogen single bond and as a result are very reactive. Many hydrazines are also toxic and/or carcinogenic. Phenyl hydrazine is the only chemical in this class that is routinely found in high school science laboratories and is less reactive and less toxic than many lower molecular weight hydrazines. It does need to be neutralized by chemical means before disposal.

EXAMPLE:

Phenyl hydrazine

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood
Large glass beaker
Magnetic stir plate
Calcium hypochlorite, $Ca(OCl)_2$, tenfold molar excess

CHEMICAL CONCEPT:

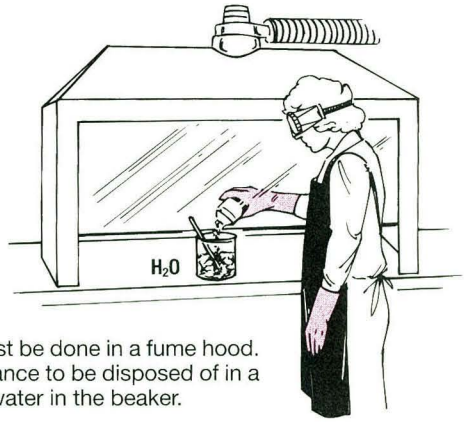
This procedure is similar to #14. The phenylhydrazine is oxidized by hypochlorite to benzene, nitrogen, and salt.

$$C_6H_5NHNH_2 + OCl^- \rightarrow C_6H_5 + N_2 + NaCl + H_2O$$

FLINN METHOD #16 continued on next page.

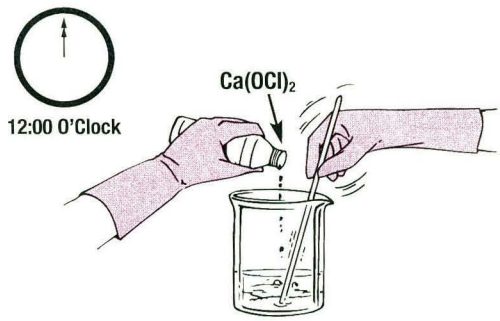
FLINN METHOD #16 *continued*

PROCEDURE:



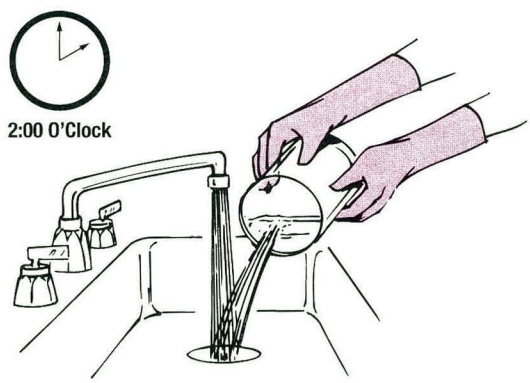
1

This procedure must be done in a fume hood. Dissolve the substance to be disposed of in a 20-fold excess of water in the beaker.



2

Slowly add solid calcium hypochlorite (1 g per g hydrazine) while stirring; monitor the temperature of the solution. It should rise, but if the solution becomes very hot, reduce the rate of addition of calcium hypochlorite.



3

About two hours after completion of the addition of calcium hypochlorite, flush the mixture down the drain with a 20-fold excess of water.

FLINN METHOD

#18a VOLATILE HYDROCARBONS, ALCOHOLS, KETONES, ESTERS

Many low molecular weight organic compounds that contain only carbon, hydrogen, and oxygen are volatile and have low toxicity. These materials are very flammable and need to be evaporated. If the material is water soluble, check with your local wastewater treatment facility to determine if it can be disposed of down the drain.

EXAMPLES:

Hexanes, isopropyl alcohol, acetone

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Shallow metal or glass pan
Efficient fume hood, or site for outdoor evaporation
Dry chemical (ABC) fire extinguisher (optional)

CHEMICAL CONCEPT:

No concept statement judged necessary for this procedure.

PROCEDURE:



This procedure should only be used for small amounts (<500 mL) of materials. These materials are flammable, so remove any sources of ignition and have a fire extinguisher available. Place a shallow pan in your fume hood. Pour a shallow layer of the substance to be disposed of in the pan and allow the natural air movement in the hood to evaporate the material. If you do not have a hood, the evaporation may be done outdoors, but it is required that the process be attended at all times.

If neither of the above options is appropriate, the materials can be burned (see Flinn Disposal Method #26c).

FLINN METHOD

#18b NON-VOLATILE HYDROCARBONS, KETONES, ESTERS, ALCOHOLS, AND THEIR SOLUTIONS

Non-volatile 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 or by burning. Please consult Flinn Disposal Method #26c for proper burning procedure.

EXAMPLES:

Naphthalene, benzophenone, butyl stearate

Please...Read the Narratives

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FLINN METHOD
#20 ORGANIC AMIDES

Organic amides can be hydrolyzed back to the corresponding carboxylic acid and amine by refluxing in concentrated hydrochloric acid. This procedure is hazardous and frequently results in materials that are still not easily disposed. The best disposal procedures available to schools are disposal by a licensed hazardous waste disposal firm or by burning. Please consult Flinn Disposal Method #26c for proper burning procedure.

EXAMPLES:
Acetanilide, sulfanilamide

FLINN METHOD
#22a PEROXIDES, INORGANIC

Inorganic peroxides are strong oxidizing agents. When in contact or mixed with organic or combustible materials, fires or explosions are possible. Do not throw these materials in the trash.

EXAMPLES:
Hydrogen peroxide, sodium peroxide

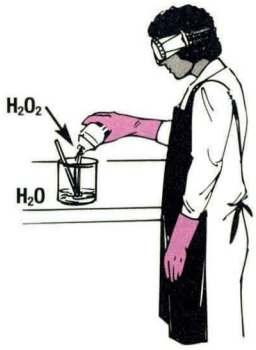
MATERIALS REQUIRED:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Large beaker, ¾ full of water
Plastic spoon (optional)
Glass stirring rod
pH indicator paper
1 M sodium metabisulfite, $Na_2S_2O_5$
3 M hydrochloric acid, HCl

CHEMICAL CONCEPT:
Hydrogen peroxide is destroyed by reducing with sodium metabisulfite or diluting it with water to less than 3% and flushing it down the drain.

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 which should be reduced prior to disposal.

$$Na_2O_2 + H_2O \rightarrow 2NaOH + \tfrac{1}{2}O_2$$
$$Na_2O_2 + Na_2S_2O_5 + H_2O \rightarrow 2NaOH + NaHSO_4$$

PROCEDURE A: Water Dilution



1a

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.

2a

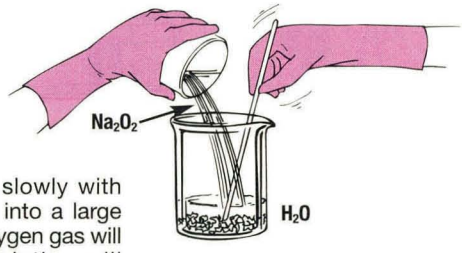
When the mixture is uniform, flush it down the drain with large amounts of extra water.





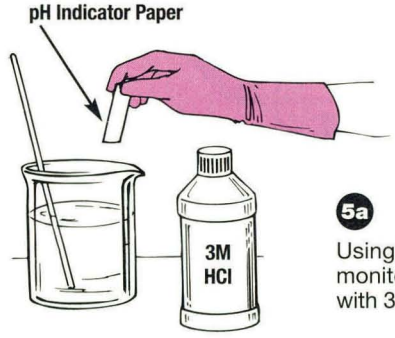
3a

If you are dealing with sodium peroxide, first break up any lumps with a dry glass stirring rod or a plastic spoon.



4a

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.)



5a

Using pH indicator paper as a monitor, neutralize the solution with 3 M hydrochloric acid.

6a

Flush the neutral solution down the drain with excess water.



FLINN METHOD #22a continued on next page.

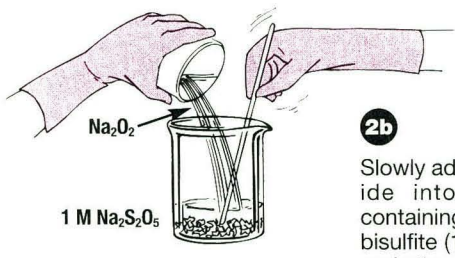
FLINN METHOD #22a *continued*

PROCEDURE B: Reduction

1b

If you are dealing with sodium peroxide, break up any lumps with a dry glass stirring rod or a plastic spoon.



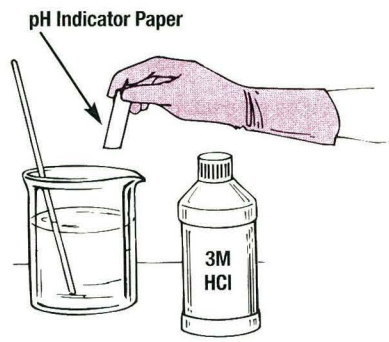


2b

Slowly add the sodium peroxide into a large beaker containing 1 M sodium metabisulfite (100 mL per g Na_2O_2) and stir continuously.

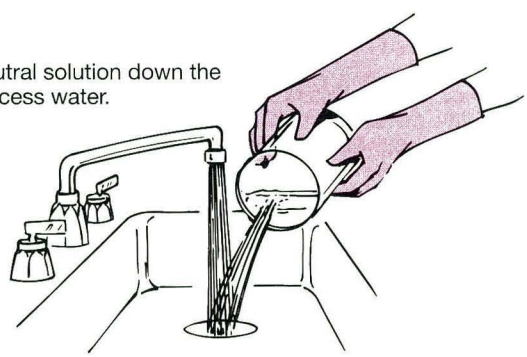
3b

Using pH indicator paper as a monitor, neutralize the solution with 3 M hydrochloric acid.



4b

Flush the neutral solution down the drain with excess water.



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 cannot be disposed of in a landfill.

EXAMPLES:

Benzoyl peroxide and lauroyl peroxide

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood
3 M sodium hydroxide solution, tenfold volume excess of the material to be destroyed, in a large glass beaker
Plastic spoon (optional)
Glass stirring rod
pH indicator paper
6 M hydrochloric acid solution

CHEMICAL CONCEPT:

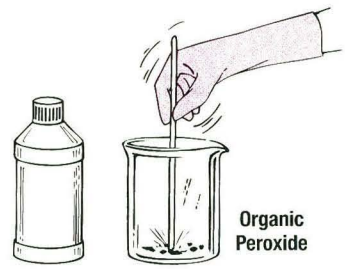
When reacted with base, benzoyl peroxide and lauroyl peroxide (the only substances we catalog for which this procedure is suggested) will cleave between the two joined oxygen atoms and form sodium benzoate or sodium laurate, which are soluble in water and innocuous. Use care not to go past the neutral point when adding acid to the aqueous solution. If the solution is acidic, some benzoic acid may precipitate out. This is not particularly harmful, but it would be better to flush the soluble sodium salt down the drain.

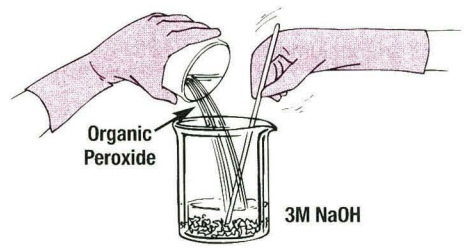
$$(C_6H_5CO_2)_2 + 2NaOH \rightarrow 2C_6H_5CO_2^-Na^+ + O_2$$

PROCEDURE:

1

Break up any lumps in the organic peroxide with a glass stirring rod or a plastic spoon.



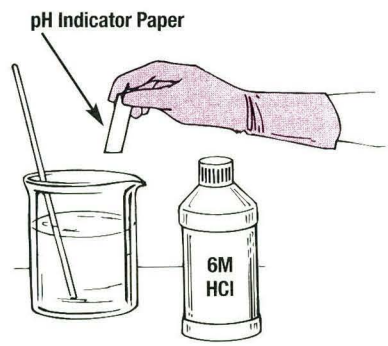


2

Pour the material into the 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.

3

Using pH indicator paper as a monitor, neutralize the solution with 6 M hydrochloric acid.

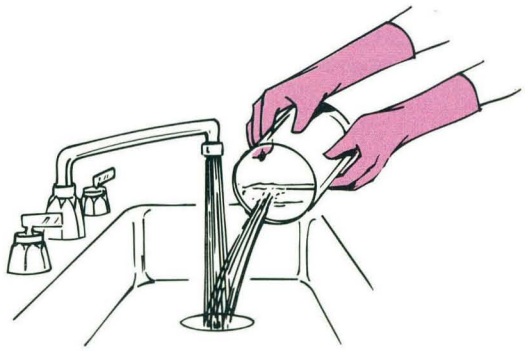


FLINN METHOD #22b continued on next page.

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. These procedures may be dangerous. Once again...read the narratives that precede these specific chemical disposal methods.

FLINN METHOD #22b *continued*



4

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 should not be disposed of in the trash or drain.

EXAMPLES:

Sodium sulfide, ammonium sulfide

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood or excellent ventilation
Large glass beaker
Glass stirring rod
Sodium hypochlorite solution, NaOCl, (laundry bleach)
0.5 M sodium hydroxide solution, NaOH

CHEMICAL CONCEPT:

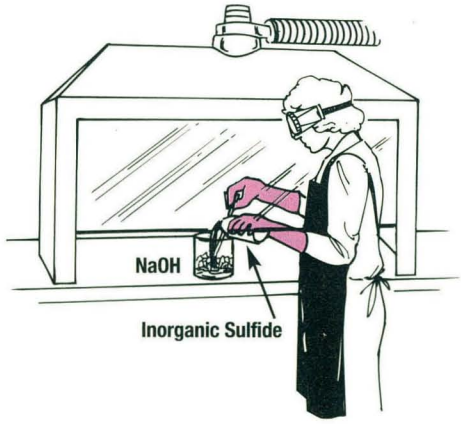
Inorganic sulfides are easily oxidized to sulfate using hypochlorites as an oxidizing agent.

$$Na_2S + 4OCl^- \rightarrow Na_2SO_4 + 4Cl^-$$

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 is more stable at a higher pH.

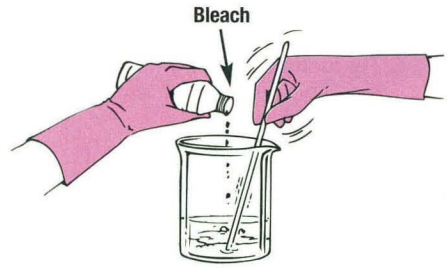
The products from the reaction are sulfate salts which are nonvolatile, odorless and have low toxicity. These materials can be flushed down the drain.

PROCEDURE:



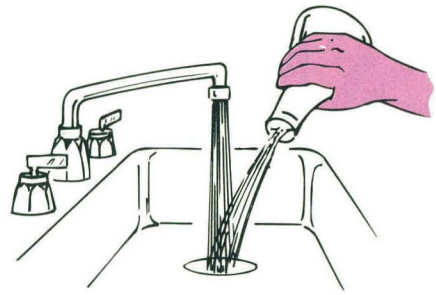
1

This procedure must be performed in a fume hood. 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.



2

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.



3

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 are best if used completely, vented in an operating fume hood for several hours, 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, and incineration. Water-soluble organic acids are best disposed of by reacting with a base to form water soluble sodium salts. Long alkyl 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 by incineration (Flinn Disposal Method #26c).

Use neutralization method for:

Acetic acid
Acetic anhydride
(Use NaOH only; the decomposition may be slow)
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

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood or excellent ventilation
Large glass beaker
Glass stirring rod
Sodium carbonate or 3 M sodium hydroxide solution
pH indicator paper

FLINN METHOD #24a continued on next page.

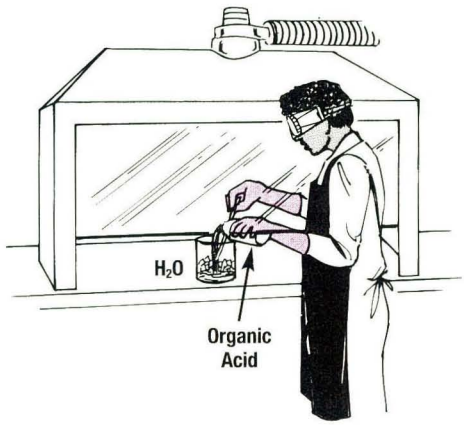
FLINN METHOD #24a *continued*

CHEMICAL CONCEPT:

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.

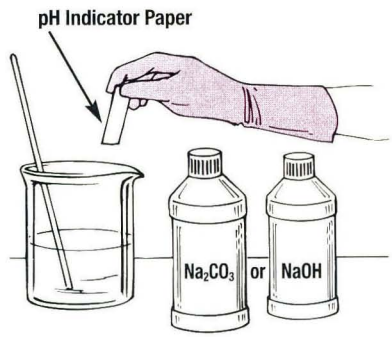
$$CH_3CO_2H + NaHCO_3 \rightarrow CH_3CO_2Na + H_2O + CO_2$$

PROCEDURE:



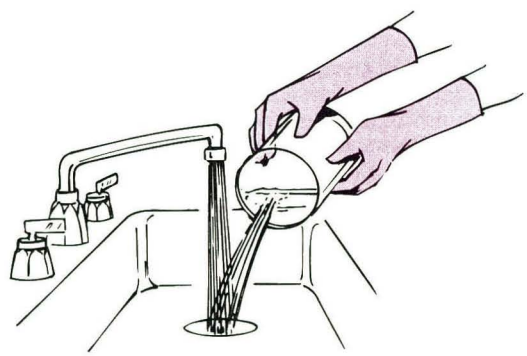
1

The organic acid may be diluted by adding it slowly to a 20-fold excess of water with stirring...



2

...neutralizing the resulting solution with sodium carbonate or sodium hydroxide solution, checking the pH with pH paper. Stir the solution until all solid organic acids have dissolved.



3

Rinse the solution down the drain with an excess of water.

FLINN METHOD

#24b ACIDS, INORGANIC

Neutralizing acid and base solutions are very common disposal procedures 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 should 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:

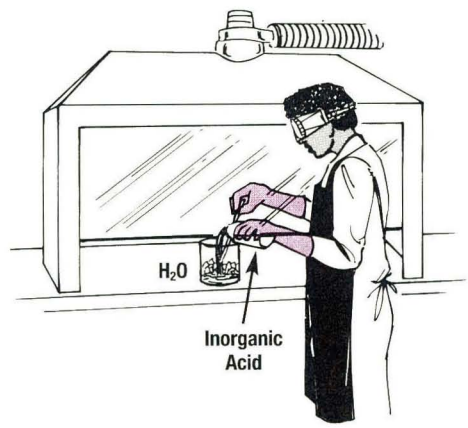
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood or excellent ventilation
Large borosilicate glass beaker less than ½ full of water
Glass stirring rod
1 M Sodium carbonate solution
pH Indicator paper

CHEMICAL CONCEPT:

This procedure is a standard neutralization of an acid with a carbonate. In the case of phosphorus pentoxide, which is an acid anhydride, reaction with water produces phosphoric acid. This reaction is highly exothermic. You may want to consider immersing your reaction vessel in an ice bath.

$$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$$
$$2H_3PO_4 + 3Na_2CO_3 \rightarrow 3CO_2 + 2Na_3PO_4 + 3H_2O$$

PROCEDURE:



1

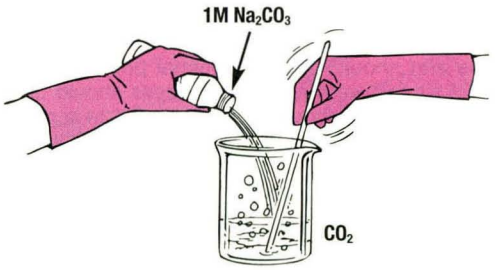
Dilute the acid by pouring it into a large beaker containing water. The final concentration of the acid should be 1 M or less.

FLINN METHOD #24b continued on next page.

Please...Read the Narratives

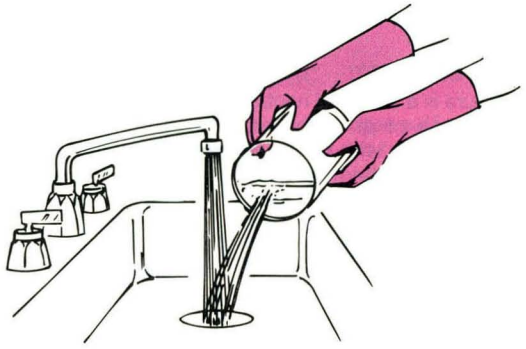
Important narratives precede these specific chemical disposal methods! Please read each narrative carefully! Do not use these procedures if you are not comfortable with the chemistry. Do not use these procedures without *first consulting with your local government regulatory officials*. These procedures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

FLINN METHOD #24b *continued*



2

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.



3

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

FLINN METHOD #25 CARBIDES

Calcium carbide reacts with small quantities of water to generate acetylene, a highly flammable gas. Decomposition under controlled conditions will produce acetylene which can be vented to a fume hood for safe disposal.

EXAMPLE:

Calcium carbide

MATERIALS REQUIRED:

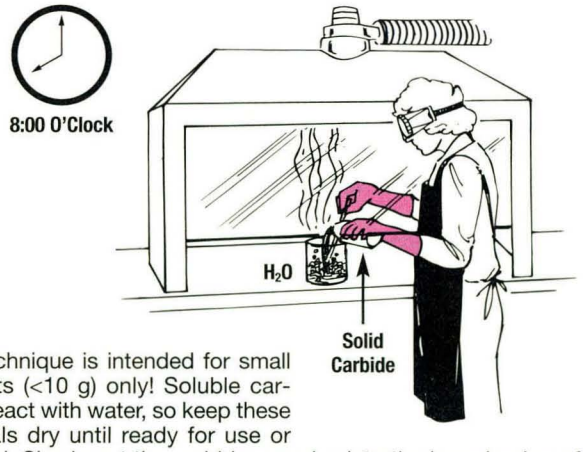
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Fume hood or outdoor site
Large glass beaker ¾ full of water
Glass stirring rod
Dry chemical (ABC) fire extinguisher
3 M hydrochloric acid
pH indicator paper

CHEMICAL CONCEPT:

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. This solution may be flushed down the drain.

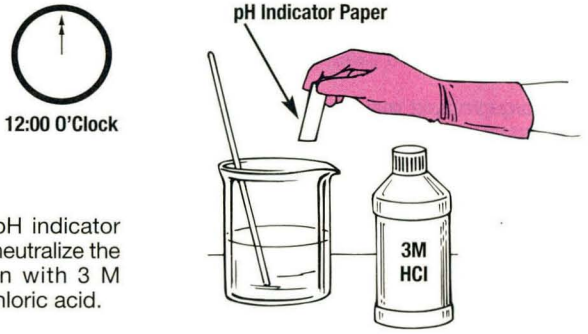
$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$
$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

PROCEDURE:



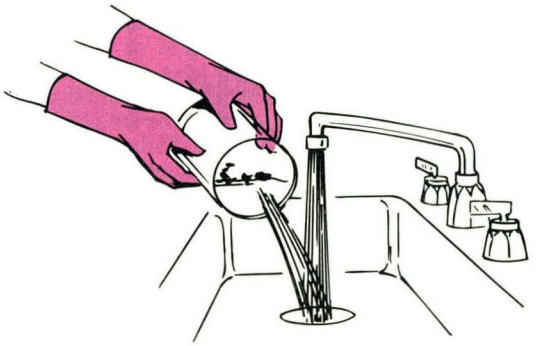
1

This technique is intended for small amounts (<10 g) only! Soluble carbides react with water, so keep these materials dry until ready for use or disposal. Slowly put the carbide granules into the 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.



2

Using pH indicator paper, neutralize the solution with 3 M hydrochloric acid.



3

Decant the neutral solution off, and flush it down the drain with a 20-fold excess of water.



4

Dry any remaining precipitate, and package it for disposal in a landfill suitable for chemical wastes.

FLINN METHOD

#26a SOLID WASTE DISPOSAL IN LANDFILL

The majority of inorganic wastes are salts consisting of a cation and an anion. In planning the disposal of these materials, the hazards associated with the cation and anion must be determined separately. If either part poises 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, Ce, Cs, Cu, Au, Fe, Li, Mg, Mo (VI), Pd, 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

CHEMICAL CONCEPT:

No concept statement judged necessary for this procedure.

PROCEDURE:



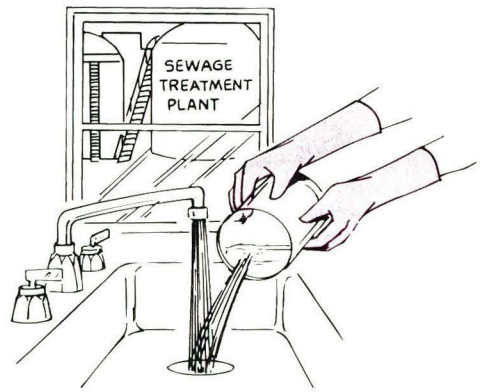
Bury these materials in a landfill site approved for the disposal of chemical and hazardous waste. Do not mix these materials by removing them from their separate containers as an unpredictable chemical reaction might occur. Rather, pack the separate containers into sturdy cardboard boxes, separating the glass containers from each other with crumpled newspapers to avoid inadvertent breakage. Seal the cardboard boxes closed 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 and hazardous waste" while full well realizing 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. We cannot possibly keep track of all the changes in all the jurisdictions governing landfills, so you must determine what is permitted in your area. Please, we exhort you, do not assume that it is acceptable simply to dump materials into the school trash. Take the time to investigate. Some teachers have made this "investigation" a student/teacher project, and have learned a great deal in the process.

If you have made solutions of the water-soluble or alcohol-soluble materials classified for disposal under this procedure, we recommend that you dispose of these solutions by Flinn Disposal Method #26b.

FLINN METHOD

#26b WASTE FOR DRAIN DISPOSAL WITHOUT PRETREATMENT



If—and only if—your school drains are connected to a sanitary sewer system, with a water treatment plant operating on the effluent from your drains, you may use this procedure. 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 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.
- Completely dissolve each substance in water in a separate container. Rinse this solution down the drain with a tenfold excess of water. Then rinse the solution of a second substance down the drain with a tenfold excess of water. Repeat as necessary.

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 such 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 burn the flammable substances and solutions according to Flinn Disposal Method #26c.

Please...Read the Narratives

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FLINN METHOD
#26c INCINERATION

Many hazardous laboratory wastes are best destroyed by combustion. Two forms of combustion are burning and incineration. Burning is just setting fire to the material where incineration is the efficient combustion of a material in the presence of auxiliary fuel in a dedicated facility. We highly recommend the incineration of hazardous materials at an approved chemical waste incinerator over open burning.

There are several problems with open burning of laboratory chemicals.

1. If the material is volatile, a significant portion of the material may evaporate and be dispensed into the atmosphere and never combust.
2. Some organic compounds undergo thermal breakdown and produce products more harmful than the starting material. Complex chlorinated hydrocarbons give off hydrochloric acid and dioxin-like substances.
3. The temperature of a bonfire is not sufficient to properly combust an organic material to carbon dioxide and water. Therefore, many unknown and possibly hazardous materials may be produced in the process. However, open burning of small quantities of laboratory chemicals may be the route that is most cost effective and least damaging to the environment. As with all procedures, please check with local authorities to be sure that burning is permitted.

INCINERATION

To properly destroy a substance by incineration, two steps are required. The first step is pyrolysis which breaks down the material by heat into gases and char (nonvolatiles). Pyrolysis requires temperatures as high as 1000 °C for as long as a second. The second step is combustion which is the reaction of the material with oxygen. To achieve good combustion, the vapors must be well mixed with an abundance of oxygen (air) as they are burning. Good combustion also requires a flame temperature around 2000 °C. Lastly, an incinerator contains a variety of scrubbers, afterburners and other pollution control devices to contain any volatile or airborne pollutants.

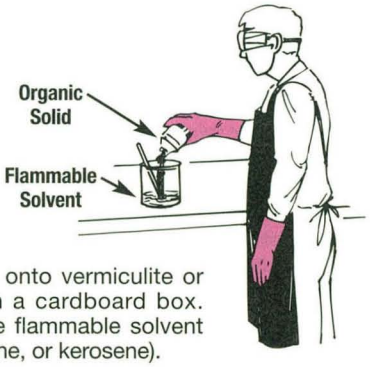
Because many laboratory chemicals requiring combustion contain highly toxic components, we highly recommend using a licensed hazardous chemical waste disposal firm to manage the combustion of chemical wastes in approved incinerators.

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Outdoor site for burning
Vermiculite or paper towels
Cardboard box about 1 foot square
Shredded paper
Scrap wood
Matches
Flammable solvent, if material to be incinerated is a solid

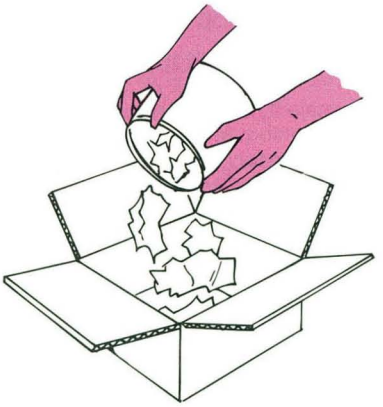
Do not burn any substance without first checking with local authorities to be sure that burning is permitted. Do not burn in an urban setting, or if burning will affect the school's neighbors.

PROCEDURE:



1

Absorb high-boiling liquids onto vermiculite or paper towels and place in a cardboard box. Dissolve solids in a suitable flammable solvent (such as ethyl alcohol, acetone, or kerosene).



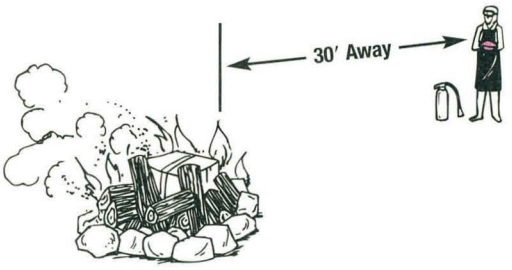
2

If the material does not appear to be soluble in a flammable solvent, make a suspension. Absorb the solution or suspension onto a bed of vermiculite or crumpled paper towels. Place this material in a cardboard box.



3

Select a site for a firebed that is clear of combustible materials and is upwind from neighbors. Construct a firebed—a shallow pit lined with stones. Lay scrap wood and shredded paper in the pit. Place the cardboard box containing the mixture on top of the wood and paper. Place some more wood on the cardboard box; a hot fire will be needed.



4

Light the fire and then quickly move a distance of at least 30 feet in an upwind direction. Stay with the fire, upwind, until the burning is complete.

FLINN METHOD
#27a SCRAP METALS

These metals have commercial value as scrap. If you do not wish to retain them, try to sell them. Otherwise dispose of them by 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. For disposal of mercury compounds, please see Flinn Disposal Methods #27d or #27f, depending on the compound.

FLINN METHOD

#27c PHOSPHORUS, RED AND WHITE (YELLOW)

Phosphorous is a highly reactive and very flammable material. Yellow (also called white) phosphorous is pyrophoric, a poison, and ignites spontaneously in air. Red phosphorous is not pyrophoric but is very flammable and can react explosively with strong oxidizing agents. Both chemicals must be handled and disposed of with utmost care.

EXAMPLES:
Yellow and red phosphorous

MATERIALS:
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Spatula or wedge
Heavy plastic bag

Procedure A
Fume hood
1-L glass beaker
Magnetic stirrer and stir bar
0.5 M sulfuric acid
Potassium bromate, $KBrO_3$
Sodium metabisulfite, $Na_2S_2O_5$

Procedure B
Heavy iron pan
Sodium carbonate, (soda ash), Na_2CO_3
Dry sand or a Class D fire extinguisher
Outdoor site for burning
Scrap wood
Shredded paper
Matches

CHEMICAL CONCEPT:
Phosphorous is oxidized under controlled conditions to phosphoric acid. Red phosphorous requires a twofold molar excess of aqueous potassium bromate for the oxidation reaction.

The reaction time for the oxidation of red phosphorous depends on the physical characteristics of the phosphorous. Large lumps of phosphorous may take up to 24 hours to completely dissolve and react. Smaller pieces will take less time.

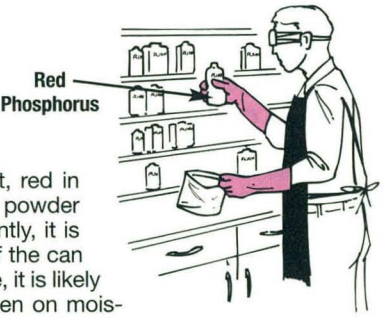
$$6P + 5KBrO_3 + 9H_2O \rightarrow 6H_3PO_4 + 5KBr$$

The excess borate should be reduced by sodium bisulfite before final disposal down the drain.

The oxidation of yellow phosphorous is extremely time consuming (requires over a week for complete oxidation) and may generate toxic by-products. We do not recommend the oxidation of yellow phosphorous as a disposal method in high school laboratories.

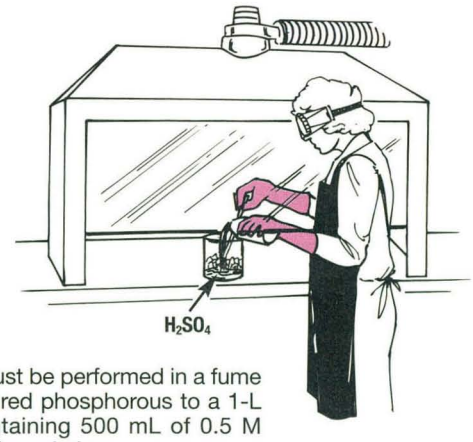
Yellow phosphorous ignites spontaneously in air and is converted to phosphorous pentoxide. Allowing small quantities of yellow phosphorus to ignite in air may be the best disposal route for schools. This procedure should only be used for small (<25 g) quantities of yellow phosphorous.

PROCEDURE A: Red Phosphorus



1a

Red phosphorus is, in fact, red in color and was originally in powder or lump form. Most frequently, it is packaged in a metal can. If the can has been stored a long time, it is likely that the contents have taken on moisture, forming phosphoric acid and are attacking the can. Your first task is to get this "mess" under control. The can may be stuck to the shelf. Using the spatula or wedge, pry the can loose and place it in a heavy plastic bag. You have now provided it with a safer home while you examine the options to get the material off the premises.



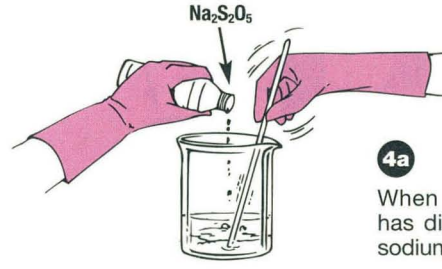
2a

This procedure must be performed in a fume hood. Add 1 g of red phosphorous to a 1-L glass beaker containing 500 mL of 0.5 M sulfuric acid. Stir the solution.



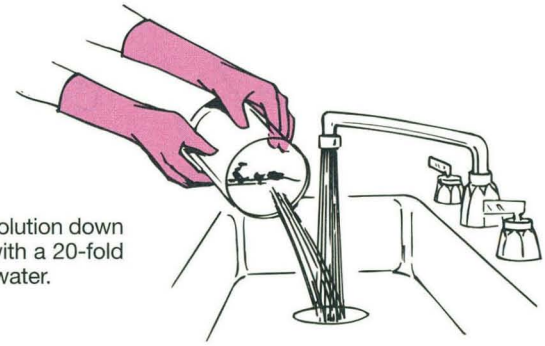
3a

Add 12 g of potassium bromate while stirring. Stir the mixture until all the phosphorous has dissolved. This step may take as long as 24 hours. If all the phosphorous is not dissolved in 24 hours, add more potassium bromate.



4a

When all the phosphorous has dissolved, add 16 g of sodium metabisulfite.



5a

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

FLINN METHOD #27c continued on next page.

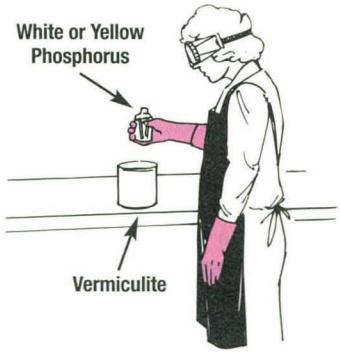
Please...Read the Narratives

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. These procedures may be dangerous. Once again...read the narratives that precede these specific chemical disposal methods.

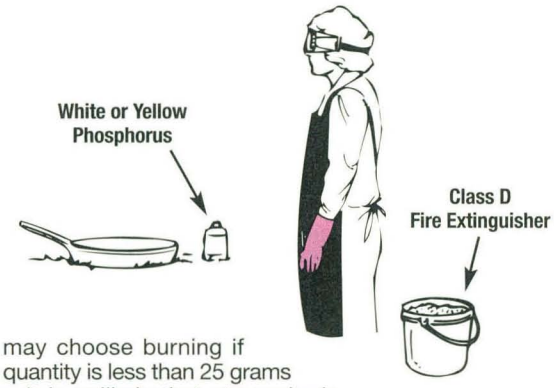
FLINN METHOD #27c *continued*

PROCEDURE B: White or Yellow Phosphorus

1b

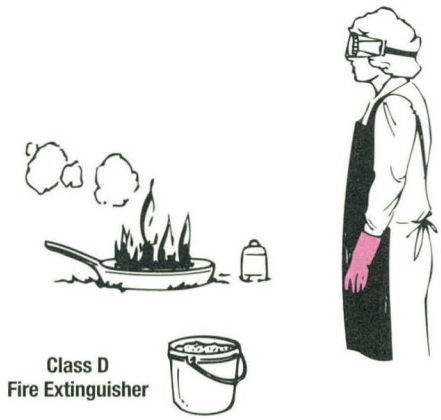


White phosphorus and yellow phosphorus are two names for the same substance. The yellow form has some colored impurities. This material is a waxy solid, usually in the form of a stick. It is stored under water at all times, as it is extremely reactive with air. It may be in a glass jar inside a metal can, or just in a metal can. You have two disposal options: removal by professionals or burning at a remote site. If you choose professional removal, make sure the phosphorus is completely submerged in water, in a glass container with a plastic cap. Place this glass container inside a metal container packed with vermiculite or bentonite. Label the can clearly. Give it to the professional. Call us if we can help you further.



2b

You may choose burning if your quantity is less than 25 grams or so. It is unlikely that atmospheric contamination from this amount of material should cause concern. Transport the material in its original container, along with a heavy iron pan and a Class D fire extinguisher or dry sand to a remote site.



3b

Pour off the water covering the phosphorus, and place the phosphorus in the iron pan. Set the pan on the ground. As the water evaporates from the surface of the phosphorus, it will start to react with oxygen in the air. The phosphorus will slowly heat up, due to the spontaneous reaction, and begin emitting enormous volumes of white smoke. This smoke is phosphorus pentoxide and is very acidic. Do not breathe this smoke. Stay upwind until the smoke subsides.

Do not burn any substance without first checking with local authorities to be sure that burning is permitted. Do not burn in an urban setting, or if burning will affect the school's neighbors.

FLINN METHOD #27d ANTIMONY, ARSENIC, VANADIUM AND THEIR COMPOUNDS: CADMIUM AND OTHER HEAVY METALS AS ELEMENTS

This procedure has been combined with Flinn Disposal Method #27f. Please refer to the following procedure.

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www.flinnsci.com

FLINN METHOD #27f HEAVY METALS AND THEIR SALTS AND COMPOUNDS

The heavy metal elements have limited reactivity and low solubility in water. These materials, while in metallic form are less hazardous. Examples include lead, antimony, cadmium, chromium, cobalt, and nickel metals.

Heavy metal salts are very soluble in water, extremely toxic, and accumulate in body tissues. The soluble salts must be converted into a stable, insoluble salt that can be buried in a landfill approved for disposal of hazardous wastes. Heavy metal cations that are suitable for this procedure include antimony, arsenic, cadmium, chromium, cobalt, lead, mercury, and nickel. This procedure converts them into their most insoluble form, and we believe it is appropriate to bury the resulting solids in a landfill approved for the disposal of hazardous waste. As always, check with your local landfill operator about proper disposal procedures.

EXAMPLES:

Lead nitrate, arsenic trioxide, mercuric chloride

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood
Large beaker
Glass stirring rod
3 M hydrochloric acid
3 M sodium sulfide solution
0.5 M sodium silicate solution
(prepare by diluting 1 part Water Glass solution (S0102) with 7 parts water)
pH indicator paper
1 M sulfuric acid
3 M sodium hydroxide solution
Filtration apparatus
Plastic container with screw-top, size dependent on amount of material

CHEMICAL CONCEPT:

Heavy metal ions react with sulfide ion to precipitate extremely insoluble sulfide solids. The sulfides are somewhat more soluble in acidic solution, so it is wise to make sure the pH is ≥7 after the precipitation of the sulfide is complete. If the supernatant liquid tests basic, do not bother adjusting the pH.

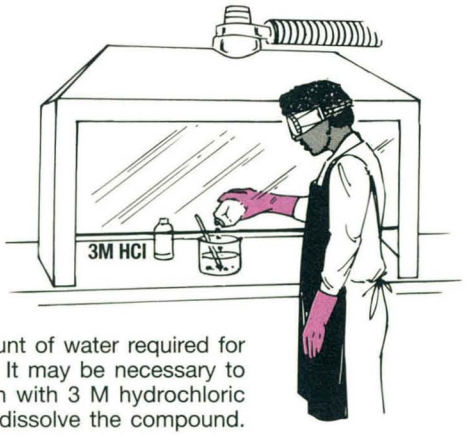
$$Hg^{+2} + S^{-2} \rightarrow HgS \text{ (solid)}$$

A second procedure is also available that converts soluble metal salts to insoluble metal silicates. This procedure is recommended for cadmium, antimony, and lead salts. Metal silicates are less reactive than metal sulfides and equally insoluble.

$$Cd^{+2} + SiO_3^{-2} \rightarrow CdSiO_3 \text{ (solid)}$$

FLINN METHOD #27f continued on next page.

FLINN METHOD #27f *continued*



1a

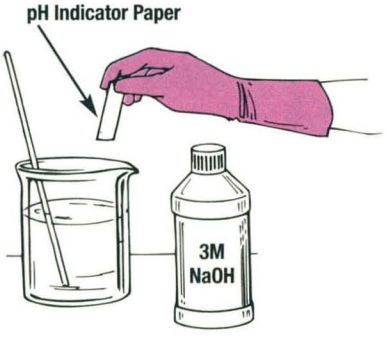
PROCEDURE
A: Sulfides

Procedure must be performed in a fume hood. Dissolve the heavy metal compound in the minimum amount of water required for complete solution. It may be necessary to acidify the solution with 3 M hydrochloric acid to effectively dissolve the compound.



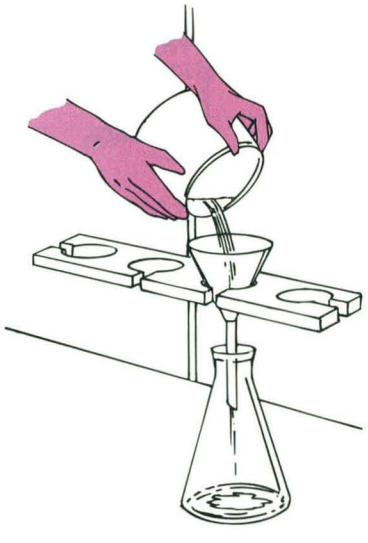
2a

Add a threefold molar excess of sodium sulfide solution to the heavy metal solution and stir occasionally for about one hour. Here is a case where we use the expression "threefold molar excess." This means you should use at least three times as many moles of the reactant as the minimum moles of disposal compound you have calculated. The reason for the excess is to make sure the complete conversion has occurred and to accelerate the rate of conversion. Please review paragraph six of the introduction entitled "Disposal Method Concepts."



3a

Adjust the pH to neutral with 3 M sodium hydroxide solution, checking with pH paper, to complete the precipitation of the metal sulfide.



4a

Separate the sulfide by decantation or filtration, and allow it to dry.



5a

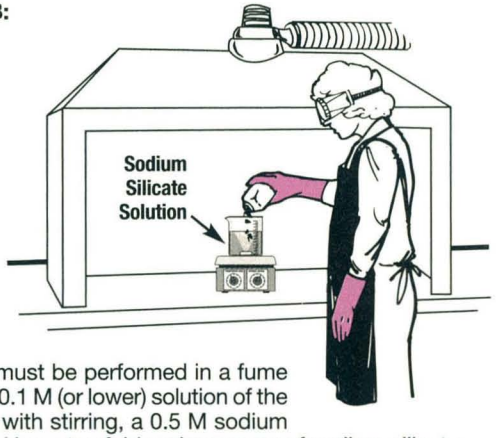
Place the metal sulfide in a plastic bag and then inside a plastic container of appropriate size, and bury it in a landfill approved for such waste.



6a

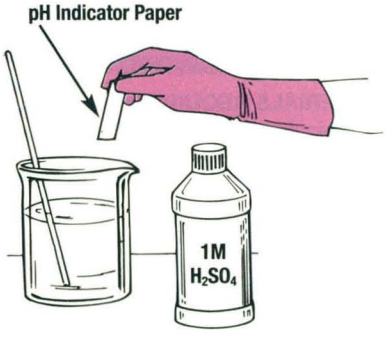
The liquid left over may have excess sulfide ion in it. It should be treated by Flinn Disposal Method #23 before disposal.

PROCEDURE B:



1b

This procedure must be performed in a fume hood. Prepare a 0.1 M (or lower) solution of the metal salt. Add, with stirring, a 0.5 M sodium silicate solution. Use a twofold molar excess of sodium silicate.



2b

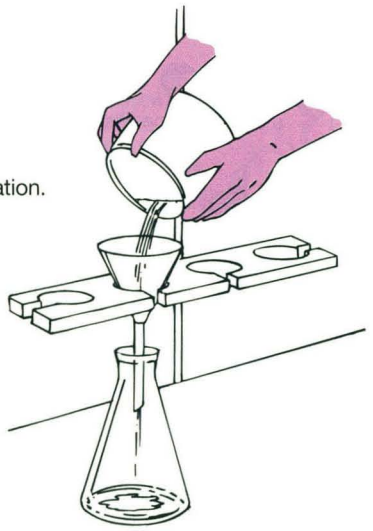
Adjust the pH to around 10 with a few drops 1 M sulfuric acid. Stir for 1 hour.

FLINN METHOD #27f continued on next page.

Please...Read the Narratives

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FLINN METHOD #27f *continued*



3b

Collect the precipitate by filtration. Allow the filtrate to dry.



4b

Place filter paper and filtrate in a plastic bag and then inside a plastic container. Bury the container in a landfill suitable for such waste.

FLINN METHOD #27h BARIUM COMPOUNDS

Soluble barium salts are extremely toxic and should not be flushed down the drain or buried in a landfill. Conversion to an insoluble barium sulfate is the best disposal route.

EXAMPLES:

All barium salts, i.e., barium nitrate, barium hydroxide, barium chloride

MATERIALS REQUIRED:

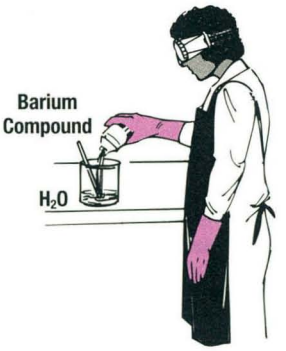
Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Large beaker
Glass stirring rod
3 M sulfuric acid
Filtration apparatus (optional)
Wide-mouth plastic container with screw top
pH indicator paper
Sodium carbonate, Na_2CO_3

CHEMICAL CONCEPT:

In contrast to the metal ions mentioned in #27f above, barium sulfide is rather soluble. However, barium sulfate is highly insoluble. This procedure produces barium sulfate in an acidic solution. Note that the only acid which 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 is complete, the precipitate is separated from the supernatant liquid and any excess acid is neutralized with sodium carbonate. The solid barium sulfate is put in a landfill, and the neutralized supernatant liquid is flushed down the drain.

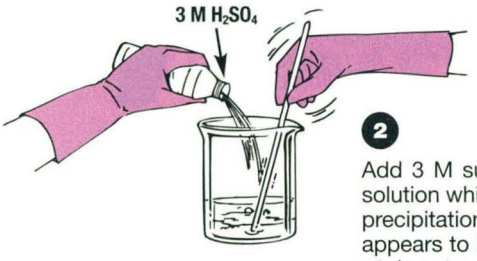
$$Ba^{+2} + SO_4^{-2} \rightarrow BaSO_4 \text{ (solid)}$$
$$2H^+ + CO_3^{-2} \rightarrow CO_2 \text{ (gas)} + H_2O$$

PROCEDURE:



1

Dissolve the solid 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.)



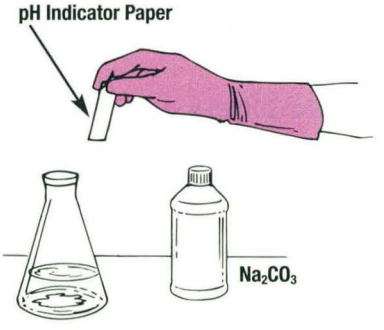
2

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.



3

Allow the precipitate to settle, and decant off the supernatant liquid or filter off the precipitate.



4

The liquid will be acidic; using pH indicator paper, neutralize it with sodium carbonate and flush it down the drain with excess water.



5

Allow the precipitate to dry, place it in a plastic bag and then in a plastic container, and bury the container in a landfill suitable for such waste.

FLINN METHOD

#27j HALOGENATED SOLVENTS

These substances are volatile, insoluble in water, and cannot be burned except in a high-temperature incinerator equipped with an afterburner and a scrubber. For small amounts, follow the procedure below. For large quantities, we recommend using a licensed hazardous waste disposal firm.

MATERIALS REQUIRED:

Chemical-resistant gloves
Chemical-resistant apron
Chemical splash goggles or full-face shield
Efficient hood or outdoor site
Iron or glass pan
Fire extinguisher

CHEMICAL CONCEPT:

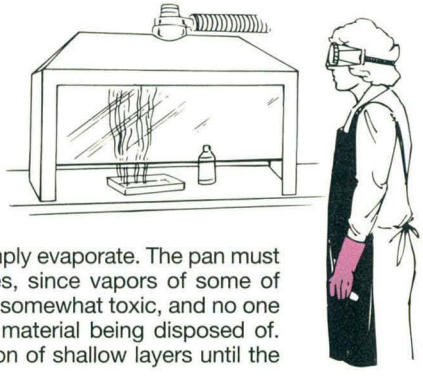
No concept statement judged necessary for this procedure.

PROCEDURE:



1

This method is recommended for small quantities only. Pour a shallow layer of the substance into the pan, and place it under an efficient hood or in an appropriate outdoor site.



2

Allow the material to simply evaporate. The pan must be attended at all times, since vapors of some of these materials may be somewhat toxic, and no one should "play" with the material being disposed of. Continue the evaporation of shallow layers until the material is gone.

Mystery Substances

Identify chemical unknowns using Flinn's Mystery Substance Identification Procedure. For a free copy of this valuable procedure, send your request to:

Flinn Scientific, Inc.
P.O. Box 219 • Batavia, IL 60510

HOW TO...

Minimize Chemical Waste

1. Maintain an up-to-date inventory of your chemicals. Eliminate buying excess or unneeded chemicals by maintaining a good chemical inventory.
2. Purchase smaller-sized containers of chemicals. Disposal of unused chemicals will always cost more than any cost savings from larger-sized packages.
3. Only purchase quantities of chemicals that can be used within five years.
4. Never accept donations of chemicals.
5. Date label all chemicals.
6. Store hygroscopic and deliquescent chemicals in *Chem-Saf*® Bags.
7. Keep the chemical storeroom cool and dry all year round.
8. Use older chemicals first.
9. Always label solutions immediately.
10. Tighten caps and lids firmly on all chemical bottles. Use Parafilm M® for extra protection on deliquescent chemicals.
11. Avoid contamination of chemicals by never returning chemicals to their containers.
12. Never store chemicals or solutions in "homemade" bottles.
13. Purchase chemical demonstration kits or chemistry student kits that contain exact quantities of chemicals.
14. Prepare only enough solution for immediate use.

REFERENCES

The disposal procedures listed in this section are obtained from the following reliable and highly regarded sources:

Lunn, G.; Sansone, E. B. *Destruction of Hazardous Chemicals in the Laboratory,* 2nd ed.; John Wiley & Sons: New York, 1984.

Laboratory Waste Disposal Manual; Manufacturing Chemists Association: Washington, D.C., 1975.

Armour, M. A., *Hazardous Laboratory Chemical Disposal Guide,* 2nd ed.; Lewis: New York, 1996.

Hazardous Chemicals, A Manual for Schools and Colleges; Oliver & Boyd: Edinburgh, 1980.

Prudent Practices in the Laboratory; National Academy: Washington, D.C., 1995.

Pitt, M. J.; Pitt, E. *Handbook of Laboratory Waste Disposal;* Ellis Horwood: Chichester, 1985.

Prudent Practices for Disposal of Chemicals from Laboratories; National Academy: Washington, D.C., 1983.

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 (school or elsewhere) 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 your state department of education. Many states have a science supervisor who might be able to make suggestions on disposal of biohazards or advise you about existing programs already in operation.
- If you are located near a large university, biological research facility, hospital, or other biological institution, check with officials for possible cooperative activities. You may be able to piggyback your biohazard materials with their disposal procedures.
- You might form a cooperative with other schools in your area and have a unified disposal plan. There are often savings in bulk disposal.
- Your state equivalent of the Environmental Protection Agency (EPA) may have useful resources.
- Your state or national biology teacher associations have resources and guidelines that are very helpful.

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

EXAMPLES:

Bacterial cultures, culture tubes, disposable loops, Petri dishes, blood typing materials, any body fluids, any unknown "growing" items, contaminated media products, disposable gloves used in dissections or when handling living materials, electrophoresis materials, any items which might harbor microorganisms.

★ HAZARDS:

All laboratory wastes that may harbor any microorganisms must be assumed to be pathogenic and need to be treated before they are thrown in the trash. Biological culture media is specifically designed to foster the growth of microorganisms. These organisms will continue to grow even after disposal unless they are destroyed. Contaminating microorganisms may be growing along with known organisms. These organisms must be assumed to be harmful. Recent concerns about blood-borne pathogens and body fluid transmissions have heightened awareness for utilizing sterile techniques when doing any human physiology experiments or blood typing. For these reasons, all of these laboratory materials must be sterilized after use and before disposal.

DISPOSAL PROCEDURES:

Materials that are potentially contaminated with microorganisms *must* first be sterilized before disposal. After sterilization, they can usually be disposed of by normal trash removal methods. Check with local authorities for rules and regulations that apply to your community. There are two methods for sterilizing wastes: Method IA—autoclaving and Method IB—chemical sterilization.

Method IA: Autoclaving

Materials can be autoclaved in an autoclave. If an autoclave is not available, a pressure cooker may be used. Biohazard bags should be used wherever possible and will make the sterilization of some biohazard materials easier, while also providing a convenient disposal container. Biohazard bags are made of a very durable plastic that can withstand the high temperature and pressure of autoclaving. An indicator patch on the bag turns dark when it has been autoclaved/steam processed. The dark patch provides quick external proof that the bag and its contents have been sterilized and that it should not be opened.

Objects to be autoclaved should be placed into a biohazard bag carefully without opening the containers (Petri dishes, test tubes, etc.). Highly dangerous materials should be handled only when wearing gloves, masks, and safety eyewear, and practicing other sterile precautions. Do not put any sharp objects (blood lancets, broken glass, dissecting instruments, etc.) into biohazard bags. The bag should then be tightly sealed by doubling over its end and sealing it shut with a twist tie. Do not overload or "stuff" the bag.

The bagged biohazard materials should now be autoclaved. The bagged biohazard materials should be autoclaved at 15 lbs. per square inch of pressure for 30 minutes at 121 °C. Follow directions for specific autoclaves or pressure cookers very carefully. Use insulated gloves when removing the bags from the autoclaving device. Bags containing glass or other breakable materials should be separated from other bags prior to disposal in the trash depending on your local practices.

Method IB: Chemical Sterilization

To sterilize, place culture or material in a 10% bleach solution for 24 hours. To prepare 10% bleach solution, dilute one part household bleach with nine parts water. Rinse the sterilized materials with water, and then dispose of them following appropriate procedures.

Type II POTENTIALLY HARMFUL WASTES DUE TO DANGEROUS CHEMICAL HAZARDS

EXAMPLES:

Solutions from electrophoresis or staining procedures, formaldehyde solutions, or other chemical solutions or solids.

★ HAZARDS:

Chemical wastes may be corrosive, toxic, or flammable and should be handled accordingly. If the waste material is of unknown composition, assume the material is toxic, corrosive, and flammable and take all precautions when handling the material. Contact Flinn Scientific technical staff 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/*

Continued on next page.

BIOLOGICAL WASTE DISPOSAL *continued*

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, an alleged 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 science laboratory.

Type IV LIVING MATERIALS

EXAMPLES:
Carcasses of dead 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 nontransparent plastic bag, and then throw it in the school's 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 Method IA or IB 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. Use either Method IA or IB for sterilizing biohazards. 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 school's 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.

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