# Chapter 7
# Chemical Disposal Procedures

There are three kinds of chemicals in the lab:

- Those that will be used soon
- Those that someone could use, if not your lab
- Those that are unusable, unreclaimable or spent

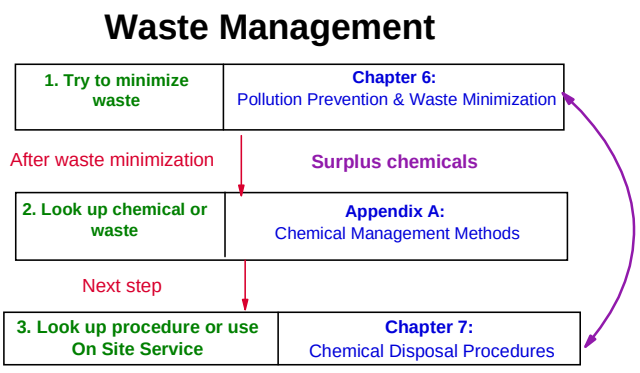
We discussed usage in Chapter 4, waste minimization in Chapter 6. In this chapter we will look at disposal. Regardless of the use, respect all chemicals for the chemical and physical properties (hazards) that they possess.

EPA and DNR laws regulate the generation, transport, treatment, storage and disposal of chemical waste.

Disposal of waste and unwanted chemicals has become increasingly complicated. The U.S. Environmental Protection Agency (EPA) and the Wisconsin Department of Natural Resources (DNR) regulate the disposal and treatment of hazardous waste, including waste laboratory chemicals. By following the procedures in this chapter, you help the University comply with these environmental laws and protect health and the environment. For more information about the details of hazardous waste laws, see Chapter 3 and Appendices B and H.

Before seeking a disposal method for your chemical waste and when planning your work, consider the pollution prevention and waste minimization methods discussed in Chapter 6. Some unwanted chemicals can be used by another lab if they are in their original containers and are in good condition. If you have surplus chemicals, call the Safety Department for on-site removal. We'll try to find another laboratory that can use them.

There are two methods of dealing with chemical products and waste:




✓ **In-Lab Chemical Management**. In-Lab Management includes simple disposal and treatment methods that can be done in your lab, such as solvent commingling, flushing down the sanitary sewer, and neutralization. These disposal procedures are described in detail on the following pages. Call the Safety Department for advise regarding the disposal of specific chemicals and wastes and, in some cases, demonstrate treatment and neutralization procedures.

Call the Safety Department at 262-8769 if you have any disposal questions.

✓ **On-Site Hazardous Materials Management**. For On-Site Service the Safety Department staff will come to your laboratory to remove those items that can be recycled, require a more complex disposal procedure, or require disposal at a commercial hazardous waste treatment, storage and disposal facility. Most of the University's hazardous waste is either incinerated in an EPA permitted hazardous waste incinerator or blended with fuel for incineration in a cement kiln to recover its heat energy.

The following instructions address a broad scope of chemical disposal situations. For customized treatment methods, individual consultation or further information on our services, please call the Safety Department.

## 7.1 In-Lab Chemical Management

There are many chemicals that can be properly disposed of by discharge into the sanitary sewer after neutralization or other chemical treatment method, by discharge into the sanitary sewer with no neutralization or other chemical treatment required, or directly into the normal trash. Deciding which disposal route is most appropriate for your material depends on the amount of waste, its chemical and toxicological properties, its environmental fate, and the capability of your laboratory.

Appendix A of this *Guide* is an alphabetical list of chemicals and their appropriate disposal procedures. If your chemical is not suitable for reuse by another lab (see Chapter 6 for suitability criteria), look it up in Appendix A for its disposal procedure. If it is listed in Appendix A you may dispose of the material in your laboratory following one of the following procedures. Some laboratories do not have the facilities for in-lab management or the personnel are uncomfortable using the disposal procedure described here. If so, use the ***On-Site Service*** procedures.

The specific procedures and waste types are detailed alphabetically in the following sections. Call the Safety Department if you have any questions.

### ⏭ Acids

Look up chemical in Appendix A, then see ***Neutralization Procedures: Strong Acids and Bases***.

### ⏭ Acrylamide

Acrylamide is a potent neurotoxin. Respiratory protection should be used when handling powder or it should be handled in a fume hood.

Most acrylamide gels can be disposed following procedure **Normal Trash 2**.

- Dispose of solid acrylamide powder using ***On-Site Service 1*** procedure.
- Acrylamide and other electrophoresis gel solutions can be polymerized and discarded in the normal trash. Acrylamide solutions should be polymerized according to the procedure given by the supplier. Discard the gel in the normal trash following ***Normal Trash 2***. If gelling does not occur, discharge to the sanitary sewer according to ***Sanitary Sewer 7***.
- Dispose of empty acrylamide containers using ***Normal Trash 4*** procedure. Remember to rinse container of dust or residuals with water and sewer rinsate.
- Alternatively, follow procedure ***On-Site Service 1*** for the disposal of acrylamide solutions.

### ⏭ Aerosol Cans

Refer to procedure **Gas 1** for disposal of aerosol cans.

### ⏭ Aqueous Solutions

Most aqueous solutions can be disposed of in the sanitary sewer.

- **Aqueous solutions of water miscible flammable organic solvents**. Solutions of <u>less than 10%</u> acetone, ethanol, methanol and other water soluble and miscible solvents, can be put down the drain followed by 10 volumes of water. These solvents are in many ways similar to an alcoholic mixed drink. One safe way to sewer them is to pour the solvent mixture directly into the drain with the faucet running for dilution. See procedure ***Sanitary Sewer 8*** for more information. Aqueous solutions of <u>more than 10%</u> of the above solvents or more than 5 liters should be disposed according to ***Organic Solvent Collection***.

- **Aqueous Solutions of Inorganic Chemicals**. Check Appendix A for the appropriate disposal procedure. Aqueous solutions of inorganic chemicals should be disposed of according to ***Sanitary Sewer 6***.
- **Aqueous Solutions of Organic Chemicals**. Check Appendix A for the appropriate disposal procedure. Aqueous solutions of organic chemicals should be disposed according to ***Sanitary Sewer 7***.

### ⏭ Bases

Look up the chemical in Appendix A, then see ***Neutralization Procedures: Strong Acids and Bases***.

### ⏭ Batteries

There are four types of batteries used on campus: automotive, ordinary alkaline, toxic metal containing (e.g., cadmium and mercury) and flammable. Each of these battery types requires a different disposal procedure:

- Batteries containing toxic metals like mercury and cadmium (i.e., rechargeable nickel-cadmium [NiCad]) should be disposed of following ***On-Site Service 1***.
- Lithium metal nickel-metal hydride containing batteries may be hazardous (flammable) and must be disposed following procedure ***On-Site Service 1***.
- Disposal of automotive (lead-acid) and smaller lead-acid batteries involves contacting the University Garage for specific instructions.
- Ordinary alkaline batteries (e.g., zinc-manganese dioxide) can be disposed in the normal trash.
- If you have a large number of batteries (i.e., more than 20) call Safety for advice.

### ⏭ Chemical Carcinogens and Mutagens

See Chapter 2 and Appendix D for a discussion of the hazards of chemical carcinogens and mutagens.

Chemical carcinogens or mutagens may be disposed of by following procedure ***On-Site Service 1*** for removal by Safety Department personnel. Alternatively, you may treat certain carcinogens and mutagens, depending on the identity and quantity of waste. Treatment methods are detailed in Destruction of Hazardous Chemicals in the Laboratory, George Lunn and Eric Sansone, Wiley and sons, 1994 2nd Edition and Hazardous Laboratory Chemicals Disposal Guide, Margaret-Ann Armour, CRC Press (Lewis), 1996 2nd Edition.

Laundry bleach, aqueous sodium hypochlorite-sodium chloride-sodium hydroxide mixture, is often seen as a panacea treatment of toxics and smellies. Hypochlorite specifically oxidizes only certain molecular functional groups. Questions to answer before bleaching your substance are: Does the chemical have the right functional group? Does oxidizing the compound solve the toxic or odor problem effectively? Another important question to answer is: Is the chemical water soluble and is it compatible with aqueous base (i.e., not an acid)? Remember, bleach solution will also lose its titer (0.71 molar chlorine) if carbon dioxide in air gets into the container over time. The acidification of chloride-hypochlorite produces chlorine (i.e., the odor of bleach).

- Chemical treatment of a substance should have a reason. Surplus or unused material in a good container and labeled as to what is the chemical, should be sufficient as is for OSHMM in-lab pickup (see Section 7.2). Toxic compounds in aqueous or organic solvent may have added hazard due to the mobility of the solvent, especially in the event of a breakage or spill. Being able to chemically eliminate the toxicity and sewer dispose the water or commingle the solvent (i.e.,

see Organic Solvent Collection) could be an advantage. Call Safety (5-5518) for more information on specific chemicals.

- Ethidium bromide disposal procedures are addressed separately below.
- Specific procedures for degradation or destruction of other carcinogens and mutagens can be obtained by calling a chemist at Safety.
- Materials for which there are no treatment methods can be disposed following procedure ***On-Site Service 1*** in Section 7.2.

### ⏭ Cyanide Salts

Water soluble cyanide salts, excluding coordination anions, (e.g., NaCN) may generate deadly hydrogen cyanide gas when combined with acids. Carbon dioxide in air will dissolve in cyanide solutions and slowly acidify cyanide ion to hydrogen cyanide, which is volatile and is the odor of such solutions. Large volumes of solutions, high concentrations and solid salts are best disposed of following procedure ***On-Site Service 1***.

For smaller quantities of lesser concentration the following procedure may be used. It describes a method to verify the oxidation of cyanide ions to cyanate. The formation of a coordination compound in step 4 indicates further oxidation is necessary before the waste can safely be disposed into the sanitary sewer. For each chemical or solute, limit daily discharges to 100 grams per principal investigator.

Follow this ONLY for small volumes of dilute solutions containing cyanide ion.

See *Hazardous Laboratory Chemicals Disposal Guide*, Margaret A. Armour, CRC Press, 1991, pp. 120-121. The procedure assumes fresh bleach is used. To check the strength, titrate. This can be done fairly crudely by following the steps, below. Conceptually, add 1 mL of bleach to 10 mL of 2.5% potassium iodide; iodine should appear. Titrate that with 5% sodium thiosulfate pentahydrate, 0.2 molar solution ( a 10 mL graduated pipette with a two-way valve bulb on it works great!) to disappearance of iodine. Full strength should draw 7.1 mL.

1. Follow procedures described in ***Planning For Neutralization of Acids and Bases*** found in ***Neutralization Procedures***, below.
2. Dilute the solution with water to a concentration not to exceed 2% w/v of cyanide ion. With this recipe, the oxidation reaction produces a temperature rise ($\Delta T$) of 25 °C (45 °F), at most. Prepare a hot water bath in a fume hood.
3. For each 50 mL of this cyanide solution slowly add 70 mL household bleach while stirring.
4. Test the solution for residual cyanide as follows:
   a. Place 1 mL reaction mixture in a test tube. Add 2 drops 5% ferrous sulfate solution. Remember, excess bleach **will** oxidize the solution.
   b. Place in hot water bath and allow to boil for 30 seconds. Cool to room temperature.
   c. Add 2 drops 1% ferric chloride solution. Add 6 Molar hydrochloric acid until the solution is acidic to litmus.
   d. If residual cyanide is present a deep blue precipitate of sodium ferricferrocyanide ($NaFe[Fe(CN)_6]$) will be formed.
5. If cyanide remains add more bleach to the reaction mixture and repeat the test for residual cyanide.
6. If no precipitate is formed wash the solution down the sanitary sewer with 20 volumes water per volume reaction mixture.

Bleach can lose its chlorine if carbon dioxide from the air gets in the container during storage. Check for oxidizing capability with KI solution ($OCl^- + 2I^- + H_2O \rightarrow I_2 + Cl^- + 2OH^-$). The same can be done for checking the reaction mixture. If $OCl^-$ is in excess, then any $CN^-$ that is in solution (i.e., not tied up) will have been oxidized.

### ⏭ Ethidium Bromide

Ethidium bromide is a powerful mutagen widely used in biochemical research laboratories for visualizing DNA fragments. For safe use considerations, refer to Section **4.6.h**. Ethidium bromide powder can be disposed following procedure ***On-Site Service 1***.

Ethidium bromide containing solutions can be disposed in the sanitary sewer, poured in a carboy or treated in-lab.

#### ▸ Ethidium Bromide 1: Aqueous solutions of ethidium bromide

- Aqueous run-off from gel staining can be sewered without concern**.**
- **Dilute aqueous solutions less than 10 mg/L** can be disposed of in the sanitary sewer. See procedure ***Sanitary Sewer 7***, below.
- **Aqueous solutions of more than 10 mg/L** ethidium bromide can be put in a carboy. See ***Organic Solvents / Yellow Carboy*** procedure, below.
- Alternatively, you can use bleach to chemically treat ethidium bromide and dispose of the resulting mixture in the sanitary sewer. Contrary to older literature, recent findings of Margaret-Ann Armour of the University of Alberta show that waste ethidium bromide solutions *can* be safely treated with common household bleach to generate a non-mutagenic (according to the Ames test - note, Ames assay doesn't detect recombinational mutations) solution of 2-carboxybenzophenone (see "Tested Laboratory Disposal Methods For Small Quantities of Hazardous Chemicals" in *Waste Disposal in Academic Institutions*, James A. Kaufman, ed., Lewis Pubishers, 1990, p. 127). Use this procedure to treat ethidium bromide solutions:
  1. Carry out these steps in a fume hood.
  2. Add 4 mL fresh bleach for every 1 mg ethidium bromide (remember, bleach can deteriorate upon exposure to air). For concentrations of ethidium bromide below 250 mg/L, add 1 mL bleach for each 1 mL solution.
  3. Stir at room temperature for 8 hours or overnight.
  4. Rinse the destroyed ethidium bromide solution down the sanitary sewer with 20 parts water.

Thus, stock aqueous solutions can be oxidized by bleach solution. Bearing in mind that oxidizing one gram of the dye or 100 ml of 1% stock concentrate will need a gallon of the 5.25% solution, and that is if its fully fresh, for at least 8 hours of stirring and enclosed to keep out carbon dioxide.

#### ▸ Ethidium Bromide 2: Acrylamide gels containing ethidium bromide

Because of their low ethidium bromide concentration, acrylamide gels containing ethidium bromide and stained absorbent materials can be disposed of in the normal trash following procedure ***Normal Trash 2***.

#### ▸ Ethidium Bromide 3: Cesium chloride / ethidium bromide solutions

Waste aqueous solutions of cesium chloride and ethidium bromide sometimes are generated as a biphasic liquid with an alcohol layer. The following procedures are all appropriate for these wastes:

- **Dilute aqueous solutions of less than 10 mg/L** ethidium bromide can be disposed of in the sanitary sewer. See procedure ***Sanitary Sewer 1***.
- **Aqueous solutions of more than 10 mg/L** ethidium bromide are best treated by using bleach to chemically treat ethidium bromide. The resulting mixture should be disposed in the sanitary sewer. Follow the procedure in **Ethidium Bromide 1**, above, to treat ethidium bromide solutions:
- Alternatively, you can dispose of your liquid following ***On-Site Service 1***.

**Ethidium Bromide 4:** Alcohol solutions of ethidium bromide

Waste alcohol solutions of ethidium bromide commonly contain butanol, *n*-propanol or amyl alcohol. Organic solvent solutions of the dye and Alcohol solutions of ethidium bromide can be commingled with waste solvents. Place them in a round carboy following the procedures for ***Organic Solvent / White Carboy***.

**Ethidium Bromide 5:** Labware contaminated with ethidium bromide

Contaminated labware includes disposable gloves, pipettes, test tubes, etc., that are contaminated with ethidium bromide. Follow the procedure below, depending on your waste type.

- **Needles, spatulas and other sharps contaminated with ethidium bromide** should be disposed of directly into the sharps container. See Chapter 9 for more information about sharps disposal.
- **Pipettes and other disposable glassware contaminated with ethidium bromide** should be disposed of in the waste container designated for glass disposal (see Chapter 9). Grossly contaminated glassware may be washed in water before disposal and the rinsate treated with bleach and sewered.
- **Test tubes and centrifuge tubes contaminated with ethidium bromide** should first be emptied, with the liquid disposed according to the appropriate procedure given above. Empty tubes can then be disposed in the normal trash (see ***Normal Trash 2***). Grossly contaminated glassware can be soaked in water prior to disposal and the rinsate treated with bleach and sewered.
- **Heat sealed tubes containing ethidium bromide** should be given to Safety for disposal according to procedure ***On-Site Service 1***.
- **Most other disposable labware contaminated with ethidium bromide** can safely be disposed of in the normal trash according to **Normal Trash 2**. If you feel that your labware contains an unusually high concentration of ethidium bromide, call the Safety Department for an evaluation, or follow procedure ***On-Site Service 1*** for removal of your contaminated labware. Water rinsate of grossly contaminated labware may be treated with bleach prior to disposal.

### Explosives and Potential Explosives

Explosive and potentially explosive chemicals may require specific handling procedures to prevent detonation. Read about reactive, explosive and shock-sensitive chemicals in Part B. If you are concerned about the potential explosive nature of a laboratory chemical, call the Safety Department for an evaluation by following procedure ***On-Site Service 3***.

### Flammable Solvents

Please refer to ***Organic Solvent Collection*** for further details.

## ⏭ Gases in Aerosol Cans and Cylinders

As with most hazardous wastes, the best way to manage gas cylinders, canisters and cartridges is to keep surplus to a minimum. This can best be accomplished by buying only what you need, by using all you buy, by emptying cylinders completely through routine use, and by not purchasing duplicate cylinders for those that are partially full in your inventory. Chapter 4 has more information on the safe management of gas cylinders. There are two types of cylinders used on campus:

Minimization is the best disposal route for gas cylinders.

- Cylinders supplied by our industrial gas vendor (containing argon, $CO_2$, He, $N_2$, $O_2$, air and other common gases) usually in 50-inch cylinders and distributed by Material Distribution Services.
- Specialty gases, supplied by various vendors, usually in lecture bottles (usually 12-inches long).

### ▸ **Gas 1:** Aerosol cans

Aerosol cans cover a wide spectrum of agents. Disposal should consider the kind of aerosol, the propellant, status of the can. Types of aerosols include:

- ✓ pesticides,
- ✓ paint, hair spray lacquer, lubricants,
- ✓ foams (shaving cream, whipped cream, oven cleaner, etc.),
- ✓ propellant for spray reagents (Berneulli effect),

The type of propellant or material in the can:

- ✓ solid dissolved in a liquid and charged with a gas.
- ✓ liquid charged with a gas.
- ✓ gas only (e.g., freon, $CO_2$, $N_2$, etc.)

The actual quantity of material remaining in the can:

- ✓ can is full
- ✓ can is partially full
- ✓ can has material, but no pressure
- ✓ can is empty

Additionally, the operability of the valve is important:

- ✓ valve for making spray is missing, doesn't work or container needs a spray devise that is no longer available.
- ✓ valve can be made to operate.

Aerosol cans can be sprayed out until empty and disposed of in the normal trash. Spraying out a full can, however, is tedious and messy. For cans of hazardous substances that are not empty but have no propellant, use ***On-Site Service 1*** for disposal.

### ▸ **Gas 2:** Return of gas cylinders to Material Distribution Services

Cylinders obtained from Materials Distribution Services (MDS) are to be returned for reuse. The valve protection cap must be in place for transport. Call MDS for pickup.

### ▸ **Gas 3:** Return of gas cylinders to supplier

Most lecture bottles can be returned to their supplier or manufacturer.

1. Contact the manufacturer or vendor of the gas cylinder in question to see if it can be returned for reuse.

2. Follow the instructions given by the vendor to ship the cylinder. Call the Safety Department if you need help.
3. If the manufacturer or vendor will not allow for return, follow procedure ***Gas 4*** for atmospheric gases and ***Gas 5*** for other gases.

### ▸ Gas 4: Venting of atmospheric and inert gases

Do **NOT** vent nitric oxide (NO). It is extremely toxic.

Cylinders of atmospheric and inert gases that are not returnable or emptied may be disposed of by venting in a properly functioning fume hood. Gases suitable for venting include: argon (Ar), carbon dioxide ($CO_2$), helium (He), krypton (Kr), neon (Ne), nitrogen ($N_2$), and xenon (Xe). Nitrous oxide ($N_2O$) and oxygen ($O_2$) must be vented slowly. **DO NOT vent nitric oxide (NO)** as it is an extremely toxic gas. Do not attempt this procedure unless you are confident that you can do it safely. If you are uncomfortable venting the gas, dispose of cylinder following procedure ***On-Site Service 3***. Follow this procedure to vent your gas cylinders:

1. Call the Safety Department to verify that the gas can be vented in your lab.
2. Check your fume hood to make sure that it is functioning properly. See Chapter 4 for fume hood issues.
3. Slowly vent the cylinder in the back of the hood.
4. To verify the valve is working and to make sure the cylinder is empty, attach tubing to the valve exit and force line air into the cylinder and observe it to take air and release air.
5. Dispose of the empty cylinder following procedure ***On-Site Service 3***.
6. Remember, do not label a cylinder "empty" unless you know it is empty.

### ▸ Gas 5: Commercial disposal

Follow procedure ***On-Site Service 3*** to arrange for removal of gas cylinders for commercial treatment and disposal.

## ⏭ Inorganic Chemicals

Look chemical up in Appendix A for specific disposal procedure.

- **Solids and reusable solids** in their original container can be disposed following procedure ***On-Site Service 1***.
- **Gases**. See ***Gases in Aerosol Cans and Cylinders***, above.
- For **inorganic solutes in an aqueous solution**, follow the procedure for ***Aqueous Solutions***, above.
- For a **contaminant on labware**, see ***Labware Contaminated With Chemicals***, below.

## ⏭ Labware Contaminated with Chemicals

Most contaminated labware can be washed for reuse.

Contaminated labware includes disposable gloves, aprons, bench top coverings, centrifuge tubes, pipettes, pipette tips, test tubes, and unwanted glassware and other items that are contaminated with a chemical. This is a very large laboratory waste-tream. Its hazard depends on the amount, toxicity and environmental fate of the contaminant.

Collections of chemical samples, usually in milligram amounts in small vials, from synthesis or systematic testing should be kept together in an orderly manner and at least group labeled if not individually. Disposal to our contractor is best

accomplished if these items have an identity and are not in a heap, as though they were trash.

Many of these items are typically cleaned and reused -- and this is the best way to minimize this waste. The vast majority of waste labware that is not reused can safely be disposed of in the normal trash or the appropriate sharps or glass disposal container. To minimize the amount of waste contaminated labware that needs to be disposed commercially, decontaminate grossly contaminated labware whenever possible (see procedure ***Labware 3***). Keep contaminated labware separate from non-contaminated labware whenever possible by using separate waste collection containers.

The U. S. Environmental Protection Agency regulates disposal of certain toxic chemicals under the ***Toxicity Characteristic Leaching Procedure*** or ***TCLP*** (40 CFR 261). This method simulates the ability of a compound to leach out of a landfill into groundwater. It extracts that which is soluble in acetic acid / water solution and uses gas chromatography or atomic absorption to detect the chemical in the leachate. How they do the TCLP for vinyl chloride gas is an interesting question. At 5 mg/L in water at 55 °C, the vapor pressure would be about 2.7 mmHg. So, at the low concentration that TCLP measures (0.2 - 10 mg/L), loss to evaporation from solution may be minimal. Some of these compounds are very insoluble in water (hexachlorobenzene is 6 µg/L) and TCLP may not see them anyway. Volatile liquids would have to be tightly bound to absorbent to contaminate it for any time. Silica gel is one kind of absorbent that can do this. What the elements and their myriad compounds do is dependent on specific properties, so the TCLP certainly safe-sides risk.

The following chemicals are currently listed as having the characteristic of toxicity by the U.S. EPA:

**Toxicity Characteristic Chemicals**

| | | | |
|---|---|---|---|
| Arsenic | *o*-Cresol | Hexachlorobenzene | Pyridine |
| Barium | *p*-Cresol | Hexachlorobutadiene | Selenium |
| Benzene | Cresol, total | Hexachloroethane | Silver |
| Cadmium | 2,4-D | Lead | Tetrachloroethylene |
| Carbon Tetrachloride | 1,4-Dichlorobenzene | Lindane | Toxaphene |
| Chlordane | 1,2-Dichloroethane | Mercury | Trichloroethylene |
| Chlorobenzene | 1,1-Dichloroethylene | Methoxychlor | 2,4,5-Trichlorophenol |
| Chloroform | 2,4-Dinitrotoluene | Methyl Ethyl Ketone | 2,4,6-Trichlorophenol |
| Chromium | Endrin | Nitrobenzene | 2,4,5-TP Silvex |
| *m*-Cresol | Heptachlor | Pentachlorophenol | Vinyl Chloride |

Disposable material contaminated with these compounds must **not** be disposed of in the normal trash. They require treatment and disposal at a permitted hazardous waste facility. Follow procedure ***On-Site Service 1*** to dispose of these materials.

Contaminated labware is one of the largest waste streams at UW. Do all you can to reduce the volume your laboratory generates.

**Labware 1:** Decontamination and reuse of contaminated labware

1. Wash, empty or otherwise decontaminate chemically-contaminated labware to be reused with the appropriate detergent or solvent. An overnight soak is sufficient in most cases. Bleach is sometimes useful, but people tend to bleach anything. It is sometimes not even safe and often may not work. Call Safety for advice.

2. Dispose of the wash liquid appropriately. Most wash solutions can be disposed of in the sanitary sewer. Decant organic solvents into the proper carboy (see ***Organic Solvent Collection***, below).
3. Call a Safety Department chemist if you have any questions about decontaminating reusable items.

- **Labware 2:** Decontamination and disposal of contaminated labware

1. Wash, empty or otherwise decontaminate the chemically-contaminated metal, ceramic or glass labware with the appropriate detergent or solvent. An overnight soak is sufficient in most cases. Call Safety for advice.
2. Dispose of the wash liquid appropriately. Most wash solutions can be disposed of in the sanitary sewer. Decant organic solvents into the proper carboy (see ***Organic Solvent Collection***, below).
3. Dispose of the decontaminated wet solids in the normal trash according to the procedure for ***Normal Trash 2***.

- **Labware 3:** Chemically contaminated disposable items

Contaminated labware must be placed in a plastic bag. Liquids should be emptied into the appropriate liquid waste container. Add absorbent material (e.g., paper towels or oil dry) to absorb any remaining liquids in the bag. Volatile organic liquids will not remain contained in a plastic bag for very long, they diffuse through plastic readily.

1. **Toxicity characteristic chemicals.** If the labware is contaminated with any amount of the TCLP chemicals listed above, give the waste to the Safety Department following procedure ***On-Site Service 1***. On the "***Surplus Chemicals***" form provide a reasonable estimate of the amount of chemical in the waste container. Chemically-contaminated sharps (see Chapter 9) must be disposed in a sharps container (Note: Safety recommends you minimize use of sharps with toxic chemicals).
2. **Normal trash chemicals.** If the chemical contaminant is listed in Appendix A as having a disposal route of normal trash, the labware can safely be disposed of in the normal trash following procedure ***Normal Trash 3***, below. Follow procedures in Chapter 9 if the waste is a sharp.
3. **Hazard determination**. Most remaining contaminated labware can be disposed of in the normal trash by following procedure ***Normal Trash 3***. If decontamination of the labware is difficult, or your labware is contaminated with an extremely toxic chemical (i.e., Dioxin), or with gross amounts of a toxic chemical, the Safety Department can dispose of it according to procedure ***On-Site Service 1***. We will evaluate the waste further.
4. **Snap-top tubes**. For the 1 ml "snap top" tubes used for phenol-chloroform extraction of DNA, because of the small amount of chemical per tube, before snapping the top shut after material has been extracted, throw the open tube into a large beaker (or similar container) of water (e.g., 100 tubes could be put into 3 L of water) and the contents dissolved. Strain the tubes, sewer the water and trash the tubes. This is much better than snapping shut and saving up thousands of tubes for occasional disposal.
5. "Solid Waste". Note that merely labeling material as “solid waste” is not helpful; it can be obvious that it is solid and that one doesn’t want it. Identification should include the **hazardous ingredient(s)** and any **major components** (e.g., palladium

on celite). Waste disposal ordinances refer to “solid waste”, but that has nothing to do with our concerns (see Chapter 3 for definitions of "solid waste" and "hazardous waste").

### ⏭ Liquids

- Refer to Appendix A for the proper disposal procedure for your chemical.
- For **aqueous solutions**, see ***Aqueous Solutions***, above.
- For **organic solvents**, see ***Organic Solvent Collection***, below.
- For **strong acids or bases**, see ***Neutralization Procedures: Strong Acids and Bases***, below.
- For reusable chemicals in their original containers, see ***On-Site Service 1***.

### ⏭ Mercury

Do not dispose of **any** mercury-containing waste in the normal trash or sanitary sewer.

Mercury compounds and metallic mercury are very hazardous. Mercury is especially difficult to handle safely because it is fluid and volatile, both for how toxic it is and for a metal (0.0012 mm Hg). If spilled in a poorly vented room, mercury residue in the cracks of lab benches or floor tile may pose an exposure hazard for years until the mercury has evaporated. For safe use considerations, refer to Section **4.6.i**. It may be even more critical in its effect on experimental subjects such as plants, animals or cell cultures. The safety department has a mercury vapor meter that can detect vapor in the vicinity of hidden drops of the metal.

We make sure that our disposal contractor uses reclaimation of elemental mercury and retort methods for certain mercury compounds that are heat decomposed to elemental mercury. Avoid using mercury by substituting red liquid thermometers and electronic devices to measure temperature and pressure. Ask about our thermometer exchange service.

#### ▸ **Mercury 1:** Recycling of free-flowing metallic mercury from thermometers and manometers

Help us recycle mercury from your unwanted or broken mercury thermometers, manometers, switches, controllers etc. The Safety Department accepts metallic mercury and unwanted, unbroken mercury-containing devices. For free-flowing mercury from broken items follow this procedure:

1. Follow Mercury Spill Clean-up procedure in Chapter 5 to contain and collect the mercury.
2. If dealing with a broken thermometer preserve all sections containing visible mercury, especially the bulb. The capillary contains a small amount, about 10 - 100 mg of the metal.
3. Contain the mercury in a small container secure air- and liquid-tight cover. Mercury will corrode aluminum foil by amalgamating with it.
4. Dispose of the material following procedure ***On-Site Service 1***.

#### ▸ **Mercury 2:** Other mercury-containing materials such as mercury- contaminated labware, mercury salts and spill clean-up products

All materials containing mercury or its compounds must be disposed following procedure ***On-Site Service 1***. Call the Safety Department if you have any questions dealing with the disposal of mercury-containing wastes.

### ⏭ Metal Containing Compounds that are Toxic

Toxic metal containing compounds include those of beryllium and heavy metals such as arsenic, barium, cadmium, chromium, lead, mercury, osmium, selenium, thallium and vanadium.

- Disposal procedures for mercury are given above.
- Beryllium and beryllium dust must be given to the Safety Department following procedure **On-Site Service 1**.
- Solid compounds containing toxic metals can be disposed following procedure ***On-Site Service 1***.
- Some dilute solutions of toxic metals may be disposed of in the sanitary sewer. See procedure ***Sanitary Sewer 6***.
- Items contaminated with a toxic metal should be managed according to the procedures for ***Labware Contaminated With Chemicals***, above.

### ⏭ Neutralization Procedures: Strong Acids and Bases

It is the policy of the University Chemical Safety Committee that people who use strong acids and bases are responsible for their neutralization and disposal. Neutralization is the most efficient and least costly way of managing waste acids and bases. This policy shares the burden for hazardous waste management with those people who generate the waste. Before you use acids, bases or any other chemical, your supervisor or principal investigator must train you to safely handle and dispose of these compounds.

This section addresses the neutralization of acids and bases listed in Appendix A. After neutralization, the warm, dilute salty water can be disposed of in the sanitary sewer.

Call the Safety Department for advice or if you have questions regarding neutralization procedures. We are available to demonstrate. Call us if your facilities (e.g., sink or fume hood) are unsatisfactory or if you have large quantities of waste acid or base to neutralize.

Safe neutralization requires care and proper equipment.
- Plan your neutralization.
- Perform all steps **SLOWLY.**
- Take special care when neutralizing strongly oxidizing acids, such as nitric or perchloric.
- Caution: Vapors and heat are generated. Perform procedures in a hood, behind a shield, wear acid-resistant hand and clothing protection.

**Do not neutralize these acids**

The following acids are very reactive or have slow solubility with water. **Do not** attempt to neutralize them unless you are expert in handling and using these acids. Dispose of these waste acids following procedure ***On-Site Service 1***.

- Acid anhydrides and chlorides
- Chlorosulfonic Acid
- Fuming Nitric Acid
- Fuming Sulfuric Acid
- Liquid halides of boron, silicon, tin, titanium and vanadium
- Liquid halides and oxyhalides of phosphorus, selenium, chromium, vanadium and sulfur

**Facilities, Personal Protection and Equipment for Neutralization**

- Carry out neutralizations in a well-ventilated fume hood. Use the sash or a safety shield for protection against vigorous reactions.
- Wear an apron, splash-proof goggles *and* a full-face shield and nitrile gloves (other glove material may not provide proper protection). Long gloves or gauntlets protect forearms from splashes.
- A five-gallon polyethylene bucket is recommended for neutralizing 1 to 10 liters. A large container is needed for addition of cold water / ice and base, and to safely stir the reaction.

**Strengths of Concentrated Acids**

| Concentrated Acid | Amount to furnish one mole of acid protons | Maximum Volume per neutralization in 5-gallon Bucket† |
|---|---|---|
| Acetic Acid (Glacial) | 57.1 mL | 3.00 L |
| Formic Acid (88%) | 43.6 mL | 2.40 L |
| Hydrochloric Acid (36%) | 83 mL | 4.40 L |
| Hydrofluoric Acid (50%) | 34.6 mL | 2.20 L |
| Nitric Acid (67%) | 67 mL | 1.00 L |
| Perchloric Acid (70%) | 83 mL | 2.00 L |
| Phosphoric Acid (85%) | 45.6 mL | 2.40 L |
| Sulfuric Acid (100%) | 27.7 mL | 0.75 L |
| Trichloroacetic Acid (30% Solution) | 535 mL | 14.00 L |

†All of these except nitric and perchloric acid are scaled to sulfuric acid, giving a 43 °C rise in water temperature when neutralized without adding ice: 10 L of diluted acid + 5 L of base + ice = full bucket.

**Planning For Neutralization**

- Before starting the procedure, calculate quantities of acid or base needed for neutralization. The relative strengths of commonly used acids and bases are summarized in the adjacent tables.
- Add the maximum amount of concentrated acid or base solution listed in the following tables to 10 L water in a 5-gallon bucket. A general rule of thumb (**not applicable** to sulfuric, nitric or perchloric) is to dilute up to 30 moles of acid protons per 10 liters of water. This should give a 40 °C rise when neutralized. Here is a useful tip in making up sodium hydroxide solution for acid neutralization: ***On dissolving sodium hydroxide pellets, flakes or grains the solution warms about ten degrees centigrade for each "normality" of concentration, each 40g per liter***. Six normal solution will be 70 °C if starting with 10 °C water from the faucet.
- If an acid mixture concentration is not known, it can be crudely measured for neutralization purposes. One milliliter of the acid mixture, diluted to 10 mL in a small Erlenmeyer flask with indicator added, can be titrated with 1 normal base (4g NaOH in 100 mL water) in a graduated pipette with a two-way pipette bulb on top to control delivery. With these proportions, the number of mLs titrant delivered to make the end-point is equal to the normality of the unknown acid (i.e., $V_a \cdot N_a = V_b \cdot N_b$, $1 \cdot N_a = V_b \cdot 1$, $N_a = V_b$).
- Try a small batch first. Measure a few milliliters of waste acid into a beaker and gradually add a measured amount of base while testing its pH and observing its reaction. Assess the amount of heat and fumes generated, and the amount of base needed. Use these observations for scaling up your neutralization. Remember that, when scaling up, the lower ratio of surface area to volume may make heat dissipation a problem. Ice, going slow and stirring all help.

Dilution will reduce the hazards of a strong acid, such as concentrated sulfuric acid.

- **Neutralize Acid 1:** Sulfuric acid - significant heat of dilution

1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.

**Strengths of Bases Used for Neutralizations**

| Base | Amount to furnish one mole of base hydroxide | Notes |
|---|---|---|
| Ammonium Hydroxide (15 Molar) | 67 mL | Must be used in a fume hood. |
| Calcium Hydroxide | 37 grams | Add as a powder to neutralize acids (dust tends to fly). |
| Magnesium Hydroxide | 29 grams | Add as a powder to neutralize acids (dust tends to fly). |
| Potassium Hydroxide | 56 grams | Dissolve 336 grams KOH per liter of water to make 6 N solution (temp rise is 82 $^{o}$C). |
| Sodium Bicarbonate | 84 grams | This is best used as a spill neutralizer. |
| Sodium Carbonate | 53 grams | This is O.K. used as a spill neutralizer. |
| Sodium Hydroxide | 40 grams | Dissolve 240 grams NaOH per liter of water to make 6 N solution (temp rise is 65 $^{o}$C). |

2. Pour amount of acid specified above slowly into water to make 3 N or less.
3. Neutralize by adding 6 N sodium hydroxide solution, stirring continually.
4. As heat builds up, add ice to dilute and cool solution.
5. Monitor pH change with a suitable indicator or check periodically with pH paper (e.g., to go from pH 2 to pH 12 takes only 30 ml of 6 N NaOH in 15 L of solution).
6. When pH > 2 is reached, the solution may be washed down the sanitary sewer with tap water rinse to clear the drain trap.

- **Neutralize Acid 2:** Concentrated acids such as formic, hydrochloric, acetic, and phosphoric acid

1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
2. Pour amount of acid specified above slowly into water.
3. Stir in 6 M sodium or potassium hydroxide solution (or other suitable base) while monitoring the pH change with Universal indicator or check periodically with pH paper.
4. Once a pH of > 2 is reached, the solution can be washed down the sanitary sewer using a large amount of tap water to clear the traps. For acetic and phosphoric acids, the pH change is more gradual with base addition.

- **Neutralize Acid 3:** Hydrofluoric acid solution

Caution: Hydrofluoric acid is extremely dangerous on contact: prevent contact with eyes or skin. Avoid inhalation of vapor, too.

1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
2. Carefully pour amount of acid specified above into water.
3. Stir in base solution as per Neutralize Acid 2, above.
4. Monitor pH changes with pH paper or a suitable indicator.
5. When a pH of > 2 is reached, the solution can be washed down the sanitary sewer with tap water rinse following.

With magnesium or calcium hydroxide, a precipitate of magnesium or calcium fluoride will appear. This precipitate may be disposed of in the sanitary sewer with the rest of the solution.

- **Neutralize Acid 4:** Oxidizing acids, especially nitric acid
  1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
  2. Carefully pour amount of acid specified above into water.
  3. Neutralize with a suitable base, even ammonium hydroxide will be O.K. If you use potassium hydroxide, a white precipitate of potassium perchlorate will form when neutralizing perchloric acid. This precipitate may be disposed of in the sanitary sewer with the rest of the solution, but make sure to clean the sink trap.
  4. Monitor pH with pH paper or other suitable indicator. Note that more concentrated nitric acid will tend to bleach the indicator.
  5. When a pH > 2 is reached, wash solution down the sanitary sewer making sure to clear the sink traps by running tap water into them. Also, remember that strong acids will have a rapid pH change between 2 and 12.

**Example Calculation**

You just moved into the lab and found the following under the hood:

300 mL of ammonium hydroxide
1.5 L of hydrochloric acid
250 mL of sulfuric acid
400 mL 20% trichloroacetic acid solution

Not knowing the purity, you decide that these items must go. How many grams of sodium hydroxide will you need to neutralize all of these items?

**Step One:** Calculate how many moles of acid protons you have.

hydrochloric acid: 1500 mL ÷ 83.0 mL/mole = 18 moles
sulfuric acid: 250 mL ÷ 27.2 mL/mole = 9 moles
trichloroacetic acid: 400 mL ÷ 871 mL/mole = 0.5 moles
28 moles acid

**Step Two:** Calculate how many moles of base you have:

ammonium hydroxide: 300 mL ÷ 67 mL/mole = 5 moles base

**Step Three:** Subtract moles of base from moles of acid:

28 moles acid - 5 moles base = 23 moles base needed

**Step Four:** Calculate the grams of sodium hydroxide you would need to complete the neutralization:

23 moles base × 40 g/mole NaOH = 920 grams NaOH

You need 920 grams sodium hydroxide to complete the neutralization.

- **Neutralize Acid 5:** 57% Hydroiodic acid

**Some** hydroiodic acid solutions are oxidized to iodine, you can use this procedure to deal with these.

  1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
  2. Dilute the dark orange/brown solution by a factor of 2 or more.
  3. Rinse bottle with water and add rinsate to rest of solution to be neutralized.
  4. If crystallized iodine remains in the bottle, dispose following procedure ***On-Site Service 1***.
  5. Add 6 M sodium hydroxide or other suitable base.
  6. Add sodium sulfite or thiosulfate to clear the interfering color.

7. When a pH > 2 is reached, solution can be washed down the sanitary sewer with water following to clear traps.

**Neutralize Acid 6:** Chromic acid cleaning solutions (can be concentrated sulfuric acid with chromate between 1 and 10%)

1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above. Limit this procedure to 20 L daily per principal investigator.
2. Pour the acid (approximately 0.75 liters) into 10 L water, same as for sulfuric acid.
3. Slowly pour 6 M sodium hydroxide into the solution, stirring continually.
4. Monitor pH change with pH paper if chromium color is too strong for the universal indicator.
5. When pH 2 is achieved reduce the orange Cr(VI) to green Cr(III) by addition of saturated sodium sulfite solution. **Do this in a hood** because sulfur dioxide is produced.
6. Add more base until this is a cloudy suspension.
7. Once a homogenous blue color is achieved the solution and precipitate can be washed down the sanitary sewer with water rinse following to clear the trap. See ***Sanitary Sewer 6*** for more details.

Always add concentrated acid or base to water as recommended in the tables to dilute them prior to neutralization.

Sodium sulfite only works with chromate at acidic pH. Hydrosulfite (dithiosulfite) works at neutral pH. Adding sulfite to an acid solution will cause sulfur dioxide to be evolved, so use a hood.

- **Neutralize Base 1:** General base neutralization such as solutions of potassium and sodium hydroxides and alcoholic sodium or potassium hydroxide cleaning solutions

1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
2. Note that effervescence on addition of acid is common with older base solutions due to carbon dioxide absorption.
3. Add up to 2 L hydroxide solution to 10 liters water.
4. Slowly add 6 N hydrochloric or other suitable acid, but **not** concentrated sulfuric acid.
5. Monitor pH changes with pH paper or phenol phthalene. **Note:** Universal indicators can air oxidize rapidly in basic solutions giving a false color change.
6. When pH < 10 is reached, solution can be washed down sanitary sewer with a water rinse to clear the trap.

It is prudent not to use nitric or perchloric acids on amine bases.

**Neutralize Base 2:** Amine solutions such as ammonium hydroxide, methyl amine, dimethyl amine, ethyl amine, and trimethyl amine

1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
2. Add up to 1.5 liters amine with 10 liters water.
3. Slowly add 6 N hydrochloric or other suitable acid, but **not** concentrated sulfuric acid. Concentrated hydrochloric acid will produce clouds of salt smoke, this is not harmful, but may cause concern.
4. Monitor pH changes with universal indicator, it will work with amines.

5. When pH < 7 is reached (with amines, a pH of 9 can really stink!), solution can be washed down sanitary sewer with tap water rinse to clear the trap.

- **Neutralize Base 3:** Volatile low molecular weight amines such as allyl amine, butyl amine, diethyl amine, ethylenediamine, morpholine, pyrrolidine and tetramethylethylenediamine
  1. Follow ***Facilities, Personal Protection and Equipment for Neutralization*** and ***Planning For Neutralizations***, above.
  2. Add up to 1.5 liters amine with 10 liters water.
  3. Slowly add 6 N hydrochloric or other suitable acid (i.e., acetic acid is great for amines, but **not** concentrated sulfuric acid).
  4. Monitor pH changes with universal indicator.
  5. When pH < 7 is reached (for these amines, a pH of 9 really stinks!), solution can be washed down sanitary sewer with tap water rinse to clear trap.

## ⏭ Normal Trash Procedures

Although certain laboratory wastes can safely be disposed of in the normal trash, great care must be taken to protect custodians, handlers and the environment. This section describes the necessary precautions for disposing of laboratory chemical waste in the normal trash.

**Precautions For Normal Trash Disposal:** Do not discard any chemical in normal trash unless Appendix A specifically lists that as a method of disposal.

**Safe and Legal Use of the Normal Trash**

**Where does it go?** When you dispose of any waste in a normal trash wastebasket on the UW-Madison campus, your laboratory waste is first brought to the normal trash dumpster (not for recycling) outside of your building. When the dumpster is emptied, the trash is mixed with other campus trash, refuse and garbage, and transported to a local sanitary landfill for solid waste. UW-Madison alone disposes of about 55 tons of solid waste every day. At the landfill, the University's waste is mixed with waste from area households and businesses.

**What happens to it?** Modern solid waste landfills are designed to prevent precipitation from entering them, and are managed to prevent liquids and hazardous waste from being disposed of there. If leachate (liquids that leach through the waste) is generated, it is collected to prevent it from reaching groundwater.

**What is the law?** You may not dispose of any regulated hazardous waste in the normal trash. Chemical hazardous waste is defined in Appendix H, **EPA's Hazardous Waste Law**. Hazardous waste includes chemicals that are:

- ✓ ignitable or oxidizers
- ✓ corrosive
- ✓ reactive, potentially explosive, or able to generate cyanide or sulfide gas
- ✓ contain a Toxic Characteristic Chemical (see ***Labware Contaminated with Chemicals,*** above)
- ✓ listed as an Acute Hazardous Waste or a Toxic Waste (see Appendix H)

*Unless this Guide specifically instructs you to dispose of a waste or chemical in the normal trash, **do not** dispose of any laboratory chemical or chemically- contaminated material in the normal trash*.

**Think of Others.** Only certain wastes (specified in this *Guide*) may be disposed of in the normal trash. To prevent risks to those who empty wastebaskets, you may not dispose of any uncontained chemical in the normal trash. To keep things neat, any liquids and wet wastes need to be absorbed or securely bagged.

**Prudent and safe use of the Normal Trash.** Accounting for these concerns and restrictions, a wide variety of laboratory waste can be safely disposed of in the normal trash. Appendix A of this *Guide* lists those chemicals that are appropriate for the normal trash, and this Chapter describes the procedures you should use. Normal trash is not without hazard: staples (that can cut) and carbon black (a known human carcinogen) is a common constituent of normal trash. Prudent use of the normal trash balances the suitability of the sanitary landfill with the capabilities of other waste disposal routes.

Absolutely no free liquids are allowed in dumpsters or in the landfill.

**Call if you have questions.** If you have a waste not covered in this guide or if you have questions about normal trash restrictions, call Safety.

### **Normal Trash 1:** Nonhazardous solid chemicals

Use this procedure for nonhazardous solid chemicals that are listed as **Normal Trash 1** in Appendix A, such as talc, silica, sulfur and carbon. Do not dispose of liquids or solutions in the normal trash.

If you have more than 5 pounds (2.3 kilograms) of any one chemical for the normal trash, call the Safety Department for further evaluation.

- Normal trash is handled roughly. To prevent exposing handlers to powders, all waste solids should be contained in a tightly closed bag, box or bottle that is packed *inside* a second box or bag (i.e., an overpack). A box overpack is preferred, especially to prevent breakage if glass is used as an inside container. Mark the overpack with the waste's identity so that handlers can be assured that the waste is safe for the normal trash.
- To further minimize the chance of breakage from handling, place more than one kilogram of a nonhazardous chemical for the normal trash directly in your building's dumpster.

Be careful about putting containers that have a "chemical" label or those if put in a lab waste basket may be viewed as misplaced by the custodians and brought to someone's attention. Persons who are unaware of the potential hazards of chemicals are often over cautious.

### **Normal Trash 2:** Nonhazardous waste that is wet

This procedure is for nonhazardous waste listed as ***Normal Trash 2*** in Appendix A and for other wastes that refer to Normal Trash 2 (e.g., gels, precipitates, semisolids, etc.). It can also be used for wet, emptied vials.

- Any waste contaminated with a Toxic Characteristic Chemical must be given to the Safety Department following procedure ***On-Site Service 1***. See ***Labware Contaminated with Chemicals*** for a list of Toxic Characteristic chemicals.
- Minimize liquids in the waste by emptying vials, decanting any excess liquids, filtering the waste or allowing the aqueous waste to evaporate in a fume hood. Dispose of liquids in the sanitary sewer or in a organic solvent collection carboy, as appropriate. Absorb any remaining liquids by adding absorbent (e.g., oil dry or absorbent paper) to the waste or in the container.

Overpack all chemicals for the normal trash.

- Normal trash is roughly handled. To keep the waste contained in the package, all waste for the normal trash should be in a tightly closed bag, box or bottle that is packed *inside* a second box or bag (i.e., an overpack). A box overpack is preferred, especially to prevent breakage if glass is used as an inside container. Mark the overpack with the waste's identity so that handlers can be assured that the waste is safe for the normal trash.
- To further minimize the chance of breakage from handling, place nonhazardous waste that is heavier than one kilogram directly in your building's dumpster.

Do not place any of these wastes in organic solvent collection carboys; carboys are only for the liquid wastes specified in the procedures for ***Organic Solvent Collection***.

### **Normal Trash 3:** Labware contaminated with chemicals

Use this procedure for chemically-contaminated labware that can be safely disposed of in the normal trash, as referenced in ***Labware 3***. See ***Labware Contaminated with Chemicals*** for more information.

- Any waste contaminated with a Toxicity Characteristic chemical must be given to the Safety Department following procedure ***On-Site Service 1***. See ***Labware Contaminated with Chemicals*** for a list of Toxicity Characteristic chemicals.
- Sharps and glass must be disposed of according to the procedures given in Chapter 9, Sharps Disposal.
- Minimize liquids in the waste by emptying vials, decanting any excess liquids, filtering the waste or allowing the aqueous waste to evaporate in a fume hood. Dispose of the liquids in the sanitary sewer or in an organic solvent collection carboy, as appropriate. Absorb any remaining liquids by adding absorbent (e.g., oil dry or absorbent paper).
- Normal trash is roughly handled. Keep waste contained by puting all waste for the normal trash should in a tightly closed bag or box that is packed *inside* a second box or bag (i.e., an overpack). An overpack is preferred, especially if the waste contains breakable items. Mark the overpack with the waste's identity so that handlers can be assured that the waste is safe for the normal trash.
- To further minimize the chance of breakage, place more than one kilogram of waste directly in your building's dumpster.

### **Normal Trash 4:** Disposal of empty containers

Insure containers are cleaned especially if using carcinogens or mutagens. To dispose of an empty container that had contained a liquid or solid chemical:

- Remove all remaining chemical from the container by normal means (e.g., pouring, draining, aspirating, etc.)
- Rinse the container until discernibly empty (i.e., at least 3 times) using a small amount of water or an alcohol or acetone rinse, which can be disposed of in the sanitary sewer. Water is preferred for rinsing, even if the chemical is only slightly soluble; try running warm water in the container while it is in a sink. If an organic solvent that is not miscible with water is used, dispose of the rinsate in an organic collection carboy (see ***Organic Solvent Collection***).
- Dispose of the container in the normal trash, a glass collection container or a sharps container, as directed in Chapter 9: Sharps Disposal.
- Dispose of empty gas cylinder by following procedure ***On-Site Service 3***.

### **Oils**

Keep used oil separate from solvents and other wastes.

We try to recycle petroleum-based oils used for lubrication of engines and machinery. This includes centrifuges, diffusion pumps and vacuum pumps used in laboratories. Do not allow cleaning solvents or other materials to be combined with used oils. Uncontaminated instrument and machine oils such as centrifuge, diffusion pump and vacuum pump oils can be disposed of by the following procedure:

1. Refer to Appendix A or call a Safety Department chemist to see if your waste oil is suitable for recycling.

2. Package each type of oil separately in containers of one gallon or less and label contents. Do not place in carboys for solvent collection or mix with other chemicals.
3. Refer to procedure ***On-Site Service 1*** for disposal procedure.
4. If the oil may contain polychlorinated biphenyls (PCBs) refer to method **PCB 1**.

### ⏭ On-Site Hazardous Materials Management (OSHMM)

See the end of this part for the procedures detailing ***On-Site Hazardous Materials Management***.

### ⏭ Organic Chemicals

- Refer to Appendix A for the proper disposal procedure for your chemical.
- For **solids and reusable solids in their original containers**, see ***On-Site Service 1***, below.
- For **organic solvents**, see ***Organic Solvent Collection***, below.
- For **gases**, see ***Gases in Aerosol Cans and Cylinders***, above.
- For a **solute in aqueous solutions**, refer to Appendix A for the proper disposal procedure for that chemical.
- For a **contaminant on disposable labware**, see ***Labware 3***.

### ⏭ Organic Solvent Collection

Five gallon (20 Liter) polypropylene plastic carboys (jugs) are used on campus for collection of waste organic solvents, their solutes and some aqueous solutions of toxic organic chemicals. If you need a carboy for your waste organic solvents, call the Safety Department for delivery to your room.

It is important to use the appropriate carboy for your waste solvents. Review Appendix A to determine the specific procedure for the solvent in question. If the material is not listed, contact a Safety Department chemist for the proper disposal procedure. We distribute two types of carboys for collecting waste solvents:

#### ⏵ Organic Solvent / White Carboy

Call Safety for carboys to be used for solvent disposal.

White, square carboys are used for collection of waste solvents suitable for fuel blending. These include non-halogenated flammable solvents such as acetonitrile, ethyl acetate, hexane, methyl alcohol and toluene. Low halogen content solvents (e.g., chlorobutane, chlorobenzene) can be included. Amines should be excluded from this collection. Follow the ***Guidelines For Using Carboys***, below.

#### ⏵ Organic Solvent / Yellow Carboy

Yellow, square carboys are used for the collection of solvent wastes that must be incinerated specifically for destruction at 99.99% level (i.e., to carbon dioxide, water and hydrogen chloride) with scrubbing for hydrogen chloride. These include halogenated solvents such as chloroform, dichloromethane (methylene chloride), Freon 113 (trichlorotrifluoroethane) and trichloroethylene. Follow the ***Guidelines For Using Carboys***, below.

#### ⏵ Guidelines For Using Carboys

The following guidelines further discuss the wastes that should not be put in carboys, obtaining and storing carboys, adding waste solvents to carboys, required record keeping and removing carboys for disposal.

**Wastes That Should Not Be Put In Carboys**

- Smaller solvent bottles are best disposed following procedure ***On-Site Service 1***.
- Do not place any centrifuge tubes, glassware, gloves, ion exchange resins, paint sludge, pipette tips, solids, syringe needles (see Chapter 9 for Sharps Disposal) or viscous solutions (such as polymers) into the carboys. They will damage our liquid transfer system.
- To prevent problems with waste compatibility and handling, and to ensure safe disposal, follow the guidelines in this chapter for each chemical and **do not** put the following chemicals in carboys:

acetaldehyde
acetic anhydride
acid chlorides
alkynes
amines with f.w. < 101 g/mole
aqueous solutions of heavy (toxic) metals
bromine
carbon disulfide
chloroformate esters
chloromethylsilanes
chloropicrin
collodion
cyanohydrins
dienes
formic acid
furan
haloalkynes
α-halocarbonyls
halogeneated organic acids
hydrazines
isocyanates
isocyanides
metal halides and oxyhalides
mercaptans
mercury/ mercury compounds
metal halides and oxyhalides
mineral acids
nitrate esters
nitrite esters
nitrosamines
nitrosourethanes
non-metal halides and oxyhalides
organic peroxides
organic solids in concentrated solution
organo metallic liquids or solutions
paint
perfluroaliphatic acids
phosphines
phosphate esters
phosphite esters
polychlorinated biphenyls (PCBs)
polymerizable monomers
polymer solutions
pyrocarbonate esters
reactives in solution such as:
alkaline metal alkyls
aluminum alkyls and hydrides
boron alkyls and hydrides
sulfate esters
sulfite esters
sulfonic acids
sulfonate esters
t-butyl hypochlorite
thallium ethoxide
thiocarbonyls

**Obtaining and Storing Carboys**

- To obtain a waste solvent collection carboy, call the Safety Department. We will schedule a delivery to your room. Alternatively, some department stockrooms stock empty carboys.
- Carboys of flammable solvents present a fire hazard, so minimize the number of carboys and volume of flammable solvents in your laboratory.
- When not in use, partially full carboys should be stored in a flammable solvent cabinet.

**Adding Waste Solvents To Carboys**

Keeping your carboys capped is a federal law.

- Organic solvents are toxic, so wear goggles, gloves and a lab coat when handling carboys or when adding solvents to carboys.
- When in use, keep the carboy in a well-ventilated area.
- Keep the carboy securely capped at all times, except when adding waste to the carboy. There are several good reasons that carboys must be capped at all times:
  - ✓ volatile solvents are toxic and evaporation into your room threatens your health;
  - ✓ if an open carboy is accidentally tipped over, the solvent spill risks a fire and the health of you and your colleagues;
  - ✓ evaporation of organic solvents causes air pollution and is an illegal disposal method
- A funnel may help prevent spills, but never leave a funnel in a carboy when you are not adding waste.
- For either of the carboys (i.e., yellow or white), do not fill the carboy above the 5-gallon graduation mark on the side. This will allow sufficient room for expansion and will help to prevent leaks.
- If you put a solvent into the wrong type of carboy, it happens, just be sure to list all of the chemicals in the carboy on the form and note the error as well.
- Adding more than a liter of an aliphatic amine (i.e., triethylamine, diethylamine, butylamine, etc.) to either carboy may result in a reaction that produces enough heat to pressurize the contents and in some cases, melt the carboy. One unfortunate example of carboy melting resulted when pyrrolidine was added to a mixture that contained 1,2-dichloroethane. Pyrrolidine being less dense, layered over the denser, halogenated mixture with a boundary of contact that concentrated the reaction (i.e., forms 2-chloroethylpyrrolidinum chloride) heat to melt the plastic. Secondary amines react with ketones, aldehydes and esters and can get too warm as a result.

**Required Record Keeping**

- To dispose of waste properly, we must know its contents. In addition, the U.S. Environmental Protection Agency requires that you identify the contents of all waste solvent carboys using the green "Waste Analysis For Carboys" form.
- To obtain carboys and green "Waste Analysis for Carboys" forms call the Safety Dept. (2-8769). We'll mail them to you. Even easier, simply connect to our web site, http://www.fpm.wisc.edu/safety and go to Chemical Safety to find "***download forms***." Some department offices and stockrooms also have disposal forms.
- It is important to keep an accurate inventory of the solvents placed in the carboy. We recommend that labs assign one person to oversee the handling of waste solvents or give large-volume users a carboy for their sole use.
- We recommend that you record all additions to your carboy. You can write these on the carboy tag, a clipboard attached to the carboy handle or a log posted nearby. When the carboy is full, summarize the information on the green "Waste Analysis for Carboys" form.
- Minimize errors in tracking the contents by replacing carboys every six months, even if they are only partially full.

## CHEMICAL INVENTORY ANALYSIS FOR WASTE SOLVENTS IN CARBOYS

| Name (print) | Department | Date | Tag Number on Carboy | Type: ☐ Round ☐ Square |
|---|---|---|---|---|
| Principal Investigator/Faculty Member/Supervisor | Building and Room Number | | Telephone Number | |

### How to Use Carboys for Collection of Waste Solvents

- Carboys are five-gallon (20 liter) polypropylene plastic carboys (jugs) available free from the Safety Department (262-8769). Use a carboy to collect your waste organic solvents and aqueous mixtures of solvents. For more information see **Organic Solvent Collection** in Chapter 7 of the UW *Chemical Safety and Disposal Guide.*
- Because the carboys will be emptied by a pump, do not put any precipitates, solids or non-fluid waste into a carboy. Please refer to the reverse of this form for chemicals that should not be disposed of in a carboy.
- **Keep your carboy securely capped at all times** except when adding solvents. This will help prevent a potentially harmful exposure to you by evaporation, spill or fire. This is a U.S. Environmental Protection Agency regulation.

### Keep Waste Solvents Separated by Type

- Designate one carboy to collect flammable, high BTU waste solvents that are suitable for fuel blending, such as acetonitrile, ethyl acetate, hexane, methyl alcohol and toluene.
- Designate a separate carboy to collect halogenated waste solvents that must be specially incinerated. This is important if you generate significant amounts of chloroform, dichloromethane (methylene chloride) and trichloroethylene waste.
- Don't be unduly concerned if you make a mistake; just list what you have added to the carboy on this form.
- Keep radioactive waste organic solvents separate from waste organic solvents that do not contain radioactive materials. Do not collect radioactive waste and nonradioactive waste in the same container or carboy. These wastes are regulated by two different Federal agencies (NRC, EPA) and disposal costs are significant. For radioactive waste, use the Safety Department's Radioactive Waste Disposal form.

### Use One Form Per Carboy

- To comply with EPA rules and regulations, you must complete this form and provide a reasonable estimate of its contents. We routinely analyze carboys to determine discrepancies between content and the information you report on this form.
- Call the Safety Department at 262-8769 or e-mail via http://www.fpm.wisc.edu/safety/Radiation/pkup.html your pick-up request within 3 days of filling your carboy.

August 2001

| SOLVENTS list the solvents you placed in this carboy | Volume in Liters |
|---|---|
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**Toxic metal content or Other Precautions**

If present, please indicate (in mg) :
Lead _____ mg
Mercury _____ mg
Arsenic _____ mg
**PCBs** _____ mg

For Safety Office use only
Gallons:
Pounds:

**Tips on Keeping an Accurate Inventory of Your Carboy's Contents**

- Put one person in charge of waste solvent collection and record keeping.
- Keep a clipboard with this form nearby.
- Remind people to note on the form each time solvents are put in the carboy; don't guess after it is full.
- For large labs, use one carboy per room or user.
- Have Safety remove your carboys more frequently to prevent record keeping problems (this also prevents evaporation errors in analysis).

## Waste Analysis for Carboys

**Please do not dispose of the following liquids in carboys:**

| | | |
|---|---|---|
| acetaldehyde | α-halocarbonyls | paint |
| acetic anhydride | halogenated organic acids | perfluoroaliphatic acids |
| acid chlorides | hydrazines | organic peroxides |
| alkynes | isocyanates | phosphines |
| amines with f.w. < 101 g/mole | isocyanides | phosphate esters |
| aqueous solutions of toxic metals | metal halides and oxyhalides | phosphite esters |
| bromine | mercaptans | polychlorinated biphenyls (PCBs) |
| carbon disulfide | mercury/ mercury compounds | polymerizable monomers |
| chloroformate esters | metal halides and oxyhalides | polymer solutions |
| chloromethylsilanes | mineral acids | pyrocarbonate esters |
| chloropicrin | nitrate esters | sulfate esters |
| collodion | nitrite esters | sulfite esters |
| cyanohydrins | nitrosamines | sulfonic acids |
| dienes | nitrosourethanes | sulfonate esters |
| formic acid | non-metal halides and oxyhalides | t-butyl hypochlorite |
| furan | organic solids in concentrated solution | thallium ethoxide |
| haloalkynes | organo metallic liquids or solutions | thiocarbonyls |

### General Guidelines for Things to Keep out of Carboys

**Very acidic, Very basic**

**Very volatile**

**Reactive:** with water, with air, strong oxidizers, strong reducers, redox, polymerizable, produces gas

**Toxic / Noxious:** Low LD/50 or TD/50, sensitizers, smelly (i.e.mercaptans)

Surplus stocks of the above chemicals are best left in their original container and disposed of following procedure **On-Site Service 1** in Chapter 7 of the *Chemical Safety and Disposal Guide.*

Addition of larger volumes of the above chemicals may present a disposal problem or a hazard with respect to compatibility of waste solvents in the carboy. However, should small volumes (< 25 ml) be introduced to a carboy, simply list the compound and volume on this form. Some of these materials may be present as unreacted materials from a process or reaction in solvents suitable for disposal using a carboy. Should this occur, estimate the concentration as best possible, and list it on the front of this form as well. See Chapter 7 of the *Chemical Safety and Disposal Guide* for disposal procedures for these chemicals.

If you have any questions regarding the disposal of waste solvents in the carboy, call the Safety Department at 265-5518.

**How is this waste generated?** (*optional* information to better understand your solvent use; check all that apply)
- ❑ Chromatography
- ❑ Extractions
- ❑ Glassware Cleaning/Preparation
- ❑ Reactions
- ❑ Other (please specify) _____

Call the Safety Department if you are interested in distillation of waste solvents. See Chapter 6 of the UW *Chemical Safety and Disposal Guide* for other information on pollution prevention and waste minimization.

**A reminder about storage of waste solvent carboys and flammable liquids in laboratories:**

- For laboratory storage of flammable liquids outside of safety cans and flammable liquid storage cabinets, limit the amount to less than 10 gallons (38 liters) of flammable liquids per one hundred square feet.
- Safety cans and flammable liquid storage cabinets must be used for storing flammable liquids greater than the above amounts.

## Flammable Liquid Tag

**HAZARDOUS WASTE**

State and Federal law prohibits improper disposal. If found contact nearest Police Departmetn, Division of Emergency Government, or Department of Natural Resources

University of Wisconsin-Madison
Safety Department
30 N. Murray Street
(608) 262-8769

Waste Flammable Liquid, n.o.s.,
(Hexane, Acetone), 3, UN1993, PGII
EPA Waste Number D001

Date: Reserved for:

Building: Round: ☐ Square: ☐


**HAZARDOUS WASTE**

This carboy is a collection container for waste organic solvents.
1. Keep cap on at all times.
2. Refer to Chapter 7 of the *Chemical Safety and Disposal Guide* for instructions.
3. Fill only to bottom of handles on carboys; that is the 5-gallon level.
4. Call the Safety Dept. for pickup within three days of being full.
5. Keep away from sources of heat, flame, or ignition.
6. If this container begins to leak, immediately call Safety (2-8769)

Carboys are for the disposal of organic solvents and their associated organic solutes. Because the contents will be emptied by a pump, do not put any precipitates, solids or non-fluid wastes into a carboy:
- ☛ flammable solvents in the round carboy
- ☛ halogenated solvents in the square carboy.

**The following chemicals should not be disposed of in carboys:**

| | | |
|---|---|---|
| acetaldehyde | hydrazines | organo peroxides |
| acetic anhydride | isocyanates | paint |
| acid chlorides | isocyanides | perfluoroaliphatic acids |
| alkynes | mercaptans | phosphines |
| amines (fw <101 g/mol) | mercury compounds | phosphate esters |
| bromine | metal halides / oxyhalides | phosphite esters |
| carbon disulfide | mineral acids | PCBs |
| chloroformate esters | nitrate esters | polymerizable monomers |
| chloromethylsilanes | nitrite esters | polymer solutions |
| chloropicrin | nitrosamines | pyrocarbonate esters |
| collodion | nitrosourethanes | sulfate esters |
| cyanohydrins | non-metal halides / oxyhalides | sulfite esters |
| dienes | organic solids in concentrated solution | sulfonic acids |
| formic acid | organo metallic liquids or solutions | sulfonate esters |
| furan | | t-butyl hypochlorite |
| haloalkynes | | thallium ethoxide |
| α-halocarbonyls | | thiocarbonyls |
| halogenated organic acids | | |

See Chapter 7 of the *Chemical Safety and Disposal Guide* for disposal instructions for these chemicals.

**You may use this tag to list each chemical component with its volume each time you add waste to the carboy. Note that you must still complete a "Waste Analysis for Carboys" form prior to pickup.**

Comments: _____

**Removing Carboys For Disposal**

- When the carboy is full, immediately call the Safety Department for removal as specified in procedure ***On-Site Service 2***.
- Replacement / additional carboys can be requested when you request a pick up.

### ⏭ Osmium Tetroxide

Osmium tetroxide solutions can be converted to a less volatile (safer) form in a variety of ways, all of them involving the reduction of tetroxide to a nonvolatile dioxide or the cyclic osmium (VI) ester. (Based on the discussion of cyclic osmium (VI) esters in *Reagents for Organic Synthesis*, L.F. Fieser and M. Fieser, John Wiley and Sons, 1967-1982.)

- Add sodium sulfite solution (prepare fresh as it slowly oxidizes to sulfate on prolonged storage) to a solution containing osmium tetroxide. A black or purple turbidity will indicate the reduction of the tetroxide to dioxide.
- Alternatively, add corn oil to the solution and shake. This method takes advantage of the double bonds of the unsaturated oil to form a cyclic osmic ester. The reaction may be slow as corn oil is not really mixable with water, but its easy and it works. The solution will become dark and a suspension will form; this is its own indication of efficiency.

### ⏭ Polychlorinated Biphenyls (PCBs)

PCB-containing materials at concentrations over 50 ppm are regulated by the U. S. Environmental Protection Agency under the Toxic Substances Control Act (TSCA). The following guidelines should be followed to properly dispose of PCBs:

#### ▸ PCB 1: Liquids containing PCBs

Notify the Safety Department if you have PCB- containing material to dispose.

These include PCBs mixed with organic solvents, PCB solutions mixed with polymers, stock solutions, concentrated PCBs and rinsate from equipment

1. Store in a glass container, preferably 1 gallon or less, with a good cap that does not leak. Do not place PCB materials in solvent carboys.
2. Clearly label that the contents are PCBs. Pre-printed stickers are available from the Safety Department.
3. Keep track of all solvents and approximate PCB concentrations in the container, (e.g., 100 mL 100 ppm Aroclor 1254 in hexane).
4. When the container is 3/4 full, arrange for disposal following procedure ***On-Site Service 1***.

#### ▸ PCB 2: PCB contaminated equipment such as gloves and labware

1. Keep contaminated materials separated from liquid PCBs.
2. Place the contaminated materials in a heavy plastic bag and seal. Place the bag inside another bag (double bag), seal with tape and place inside a box.
3. Identify PCB concentration of contaminant on the white form.
4. Arrange for disposal following procedure ***On-Site Service 1***.

#### ▸ PCB 3: Electrical equipment containing PCB (or suspected PCB) oil such as fluid-filled capacitors, transformers and voltage regulators

1. Fluid-filled electrical equipment over 9 pounds may contain significant amounts of PCB oil. Suspect electrical items should be stored in plastic trays containing an absorbent to contain and absorb any spills or leaks.

2. Electrical items containing PCB oil must be carefully handled and stored in leakproof, fireproof containment areas. Oil leaking from these items will cause serious contamination necessitating enormous cleanup costs.
3. Disposal of PCB electrical equipment is strictly regulated by the U.S. EPA. The University of Wisconsin Safety Department provides sampling and analysis for PCBs and disposal of oil-filled electrical items. Please call for further assistance or information.

## ⏭ Sanitary Sewer Procedures

Many chemicals (see Appendix A) can be safely disposed of in the sanitary sewer when flushed down a sink drain with enough water to dissolve them completely.

### Safe and Legal Use of the Sanitary Sewer

**Where does it go?** When you dispose of any material or wastewater in a laboratory sink on the UW-Madison campus, your laboratory effluent is mixed with other sanitary sewage, water that the UW has used for heating and cooling, and other wastewater and enters the sewage collection system of the Madison Metropolitan Sewerage District (MMSD). UW-Madison alone discharges about 2.7 million gallons of water to the MMSD every day. In the collection system, the University's wastewater is mixed with sewage and wastewater from area households and businesses. The sewage and wastewater is conveyed to the MMSD treatment plant on Madison's south side, which treats 38 million gallons of sewage every day.

**Never put chemicals into storm sewers.** Most drains outside of buildings are storm sewers that empty directly into the lake without treatment.

**What happens to it?** Solutes that are in waste water are subject to physical degradation in the sewage system. For example, a small quantity of most organophosphate pesticides is quickly hydrolyzed in the sewer. At the treatment plant, the waste is subjected to bacterial degradation. During aeration, volatile organics can be released into the air in minute amounts. Most organic compounds and salts, such as sodium nitrate (an oxidizer) disposed of in the sanitary sewer will be used as a bacterial nutrient. There is also a tremendous degree of dilution that occurs in the system, which facilitates both of these processes.

Non-degradable chemicals, such as metals, are adsorbed on the sludge or eventually discharged to surface waters. In most cases, the concentration of chemical contaminants are so low that the sewage sludge (which is rich in nutrients) can be disposed of by application to farm land as MMSD's "Metrogro.". Land application of treated solids and disposal of treated water to surface waters are regulated by the U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources, which is the basis for the MMSD Sewer Use Ordinances, on which this *Guide* is based.

Madison drinking water is derived from groundwater, so there is no association between sewage treatment plant effluent and our drinking water. Downstream, St. Louis takes its drinking water from the Mississippi River. Dilution from the UW's laboratories to St. Louis can be estimated with the following numbers. The UW workday outfall rate is about 9 cubic feet per second. This feeds into a MMSD batch of 1.3 million cubic feet that takes 6 hours to process and dump, at 62 cubic feet per second. This enters the Rock River above Janesville with a flow of about 10,000 cubic feet per second. This river grows as it takes on other rivers and enters the Mississippi at the "Quad Cities", above St. Louis. The Mississippi is about one million cubic feet per second. Without absorption, biodegradation or volatilization

along the way, 100 grams from a lab sink becomes 2.7 ppb in a MMSD batch, 17 ppt in the Rock River and 0.17 ppt in the Mississippi.

**What is the law?** Only certain liquids and wastes (specified in this *Guide*) may be disposed of in your laboratory sink. To prevent damage to the plumbing, you may not dispose of any undiluted corrosive chemicals in your sink; corrosives must first be neutralized.

Disposal into the sanitary sewer is regulated by MMSD. To prevent explosions in the sewer system, you may not dispose of any undiluted or non-miscible flammable liquid in a laboratory sink. Polychlorinated biphenyls must not be disposed of in the sanitary sewer. Because they do not degrade, sewer disposal of toxic metals such as chromium or lead is limited to small amounts of very dilute solutions.

**Prudent and safe use of the sanitary sewer.** Accounting for these concerns and restrictions, the sanitary sewerage system is capable of safely handling and treating a wide variety of laboratory waste. Appendix A of this *Guide* lists those chemicals that are appropriate for the sanitary sewer and this Chapter describes the proper procedures you should use. This guidance has been approved of by the MMSD. The University Safety Department is in regular communication with the staff of the MMSD to ensure the University's compliance with their ordinances. Prudent use of the sanitary sewer balances the vast treatment capabilities of the sewage treatment works with the capabilities of other waste disposal routes.

**Call us if you have questions.** Please call the Safety Department if you have a waste not covered in this guide, or if you have questions about MMSD restrictions.

**Guidelines For Sanitary Sewer Disposal**

Discharge compounds to the sewer only if: (1) you are certain of its identity **and** (2) Appendix A lists the disposal procedure as Sanitary Sewer **or** (3) you have received permission from a Safety Department chemist. Some chemicals that may be disposed of in the sanitary sewer are toxic to humans. Follow these steps when discharging compounds to the sanitary sewer.

1. Don't dispose of chemicals in the sanitary sewer unless you are confident that your laboratory's sewer can handle large volumes of water and chemicals. Most laboratory sinks can be used for sanitary sewer disposal, but avoid those sinks with a history of plugging problems.
2. Refer to Appendix A for the specific procedure for your material. Remember that concentrated acids and bases must first be neutralized.
3. For each chemical or solute, each procedure has a **daily limit** in grams, liters or concentration per PI or supervisor. Be sure to coordinate your sewer disposal activities with others in your group to stay within the per principal investigator or laboratory supervisor limit. If you approach this limit, you may call the Safety Department for further evaluation or dispose of the waste according to procedure ***On-Site Service 1***.
4. Wear a lab coat, safety glasses or goggles, gloves, and avoid other potential contact.
5. Use a hood sink where available. For procedure **Sanitary Sewer 3** use of hood is mandatory.
6. Rinse out the sink to remove any residual debris and to clear the trap.
7. Dispose of a small amount of the material first, noting reactivity and solubility. To increase solubility try warm water. Do not flush materials that are insoluble.

Always use plenty of water when disposing of chemicals in the sanitary sewer.

Some chemicals (e.g., sulfates and phosphates) that are ultimately very soluble, can be slow to dissolve.

8. Dispose of small quantities at a time if possible. Limit discharges to limits set in individual procedures. If you have more than the allowable amount to dispose of, follow procedure ***On-Site Service 1*** for disposal.
9. Some of the permissible-to-sewer salts are oxidizing and may react with organic compounds and some reducing inorganics like iodide salts, sulfites, stannous salts, thiosulfates or thiocyanates. Strong oxidizers include chlorate, bromate, periodate and peroxydisulfate. It's best to avoid mixing things that are being dissolved. Even calcium salts with carbonates or phosphates can become a precipitation mess.
10. After, flush chemicals with large quantities of water (10-20 times the amount).

- **Sanitary Sewer 1:** Readily soluble solids, solutions and nonvolatile liquids

Soluble organic salts, sugars, amino acids, nucleotides, nucleosides, vitamins, acids, amines, surfactants and the many metabolic intermediates can all be disposed of in the sanitary sewer. In addition, soluble salt combinations of these ions can be discharged to the sanitary sewer system:

All material deposited in a sanitary sewer is treated prior to release back into the environment.

| Cations | | Anions | |
|---|---|---|---|
| Aluminum | Lithium | Acetate | Nitrite |
| Ammonium | Magnesium | Bicarbonate | Perchlorate |
| Bismuth | Manganese | Bisulfite | Periodate |
| Calcium | Potassium | Borate | Permanganate |
| Cerium | Rubidium | Bromate | Phosphate |
| Cesium | Sodium | Bromide | Silicate |
| Cobalt | Strontium | Carbonate | Stannate |
| Iron | Tin | Chlorate | Sulfate |
| | | Chloride | Sulfite |
| | | Cyanate | Thiocyanate |
| | | Fluoride | Thiosulfate |
| | | Iodate | Titanate |
| | | Iodide | Tungstate |
| | | Nitrate | Vanadate |

1. Follow ***Guidelines For Sanitary Sewer Disposal***, above. For each chemical or solute, limit discharges to 1000 grams per day per principal investigator.
2. Look at the label to see if it is an anhydrous aluminum or magnesium chloride or bromide (see **Sanitary Sewer 3**).
3. Slowly pour into stream of running water down drain.
4. Dispose of the rinsed, empty bottle following **Normal Trash 4**.

- **Sanitary Sewer 2:** Slowly soluble solids

This procedure is optional; you may not have the time or facilities, in which case, dispose of the material following procedure ***On-Site Service 1***.

1. Follow ***Guidelines For Sanitary Sewer Disposal***, above. The slower rate of solution of some of these will be what limits the amount of discharge per day.
2. a. Dissolve as much as possible in a bucket of water, decant and try to dissolve the remainder.

2. b. Alternatively, with water running through a colander or strainer, pour in a little of the solid (powder, crystals, etc.) at a time. Use a hood and go slowly with light, fluffy powders that tend to be airborne. Allow a stream of water to run over any undissolved material in the strainer.
3. Dispose of the rinsed, empty bottle following ***Normal Trash 4***.

Always use plenty of water when disposing of chemicals in the sanitary sewer.

**Sanitary Sewer 3:** Water reactive but suitable if dissolved

1. Follow **Guidelines For Sanitary Sewer Disposal**, above.
2. Always sewer these materials in a hood sink. If a hood sink is not available, dispose of the material following procedure ***On-Site Service 1***.
3. Pour slowly into a stream of water running across the sink to the drain. Anhydrous halogen salts of Mg, Al, Ca or Fe (most notably aluminum chloride) may hiss and generate heat as they dissolve in water. Dropping the whole bottle into water, accidentally or otherwise, may be hazardous.
4. Dispose of the rinsed, empty bottle following **Normal Trash 4**.

- **Sanitary Sewer 4:** Pretreatment prior to sewer disposal

This *Guide* describes chemical treatment procedures for acrylamide, cyanide solutions, ethidium bromide, and strong acids and bases. There exists many other simple chemical treatment procedures that can be performed in the laboratory to make the chemicals suitable for discharge to the sanitary sewer. If you generate small amounts of waste that can be readily detoxified, neutralized, oxidized, precipitated or reduced by laboratory methods, call the Safety Department for guidance.

For all chemical treatment procedures, follow ***Guidelines For Sanitary Sewer Disposal.***

- **Sanitary Sewer 5:** Malodorous but suitable for sewer disposal

This procedure is suitable for aqueous solutions of acetaldehyde, formaldehyde, glutaraldehyde, mercaptoethanol, low molecular weight amines, and sulfide solutions. In general, this procedure is for neat liquids as well as solutions addressed in ***Sanitary Sewer 8***.

1. Follow ***Guidelines For Sanitary Sewer Disposal***, above. For each chemical, limit daily discharges to 1000 grams per principal investigator.
2. The sink should be in a hood that is performing well. Pour directly into drain with water running. Don't allow the solution to spread in sink. Flush with large volumes of water afterwards.
3. Dispose of the rinsed, empty bottle following **Normal Trash 4**.

- **Sanitary Sewer 6**: Aqueous solutions of inorganic chemicals and small amounts in non-solution

Check Appendix A to be sure you can use this procedure.

Use this procedure only if you have been referred here from Appendix A or another section of this part. Follow **Guidelines For Sanitary Sewer Disposal**, above. The concentrations of the following toxic metals are regulated in the sanitary sewer. Do not exceed these daily limits for discharge per principal investigator:

| | | | | | |
|---|---|---|---|---|---|
| Arsenic | 1000 g | Chromium (VI) | 50 g | Nickel | 200 g |
| Barium | 1000 g | Copper | 150 g | Selenium | 30 g |
| Cadmium | 25 g | Cyanide | 10 g | Silver | 300 g |
| Chromium (III) | 1000 g | Lead | 500 g | Zinc | 800 g |

Concentrated solutions of these metals could be treated to precipitate and remove metals before discharge to the sanitary sewer. Adjust pH to basic side of neutrality and collect any precipitate that occurs. This will work well with silver, lead and cadmium. Chromates and dichromates can be treated with sodium bisulfite or dithionite to reduce them to Cr (III). Copper, zinc, nickel, arsenic (cacodylate buffers) and barium solutions can be sewered directly. Dispose of the precipitate via ***On-Site Service 1***. When practical, photography labs should install and maintain silver recovery units.

- **Sanitary Sewer 7**: Aqueous solutions of organic chemicals and small amounts in non-solution

Use this procedure only if you have been referred here from Appendix A or another section of this part. Follow ***Guidelines For Sanitary Sewer Disposal***, above. Aqueous solutions of biodegradable concentrations of 10% or less can be disposed of in the sanitary sewer with copious amounts of water. Degradable organic chemicals include acrylamide, nicotine, diaminobenzidine, phenol, and picric acid, as well as others listed in Appendix A. Call the Safety Department for further evaluation if you approach 10 liters of solution daily per principal investigator.

- **Sanitary Sewer 8:** Aqueous solutions of organic solvents

Solutions of these biodegradable organic chemicals used as dilute, homogenous aqueous solutions (or as aqueous extract wastes from reaction work-ups) may be safely disposed of in the sanitary sewer. These include low molecular weight alcohols, aldehydes, ketones, amines, ethers, cellosolves, nitriles, esters and nitroalkanes such as:

- methanol to pentanol
- formaldehyde to butyraldehyde
- acetone, methyl ethyl ketone
- propyl amine to piperidine
- propylene oxide, tetrahydrofuran, dioxane and diethyl ether
- methyl cellosolve and ethyl cellosolve
- acetonitrile
- methyl formate and methyl acetate
- nitroethane and nitromethane
- dimethylformamide (DMF), hexamethylphosphoramide (HMPA) and dimethylsulfoxide (DMSO)

1. Follow ***Guidelines For Sanitary Sewer Disposal***, above.
2. Limit sewer disposal of dilute aqueous solutions of these solvents to 10 liters daily per principal investigator. One important safety aspect of this is the ignitability of vapor from the solution (see Section 2.1.a). Pouring directly into the drain, avoiding spreading of liquid surface, reduces the hazard. Using the Henry's Law constant (i.e., equilibrium vapor pressure per aqueous concentration) and the "Lower Ignitable Limit" of the solvent leads to an estimation of the concentration at which a Flash Point of 25 °C (77 °F) is reached. For the alcohols, 10% is the limit (t-butanol). For aldehydes (excluding formalin solution), ketones, esters, THF and nitriles, 2% (methyl acetate) is generally safe. Diethyl ether and MTBE are at 0.2% and must be considered. The safe aspect of the low limit organics is that there is very little to flash if they were to flash.
3. Follow the solution with approximately 10 volumes of water.

4. Dispose of the rinsed, empty bottle following ***Normal Trash 4***.
5. If the material is malodorous, follow procedure ***Sanitary Sewer 5***.

### ⏭ Solids

Refer to Appendix A for disposal procedure for solid chemicals. Solids and reusable solids in their original container can be disposed following procedure ***On-Site Service 1***.

### ⏭ Solids That Are Wet: gels, precipitates and semisolids

Double-bag any wet solids to prevent leakage.

Use this procedure for solids that are wet, such as gels, precipitates, semi-solids, etc. This procedure can also be used for wet, emptied vials.

- Minimize liquids in the waste by emptying vials, decanting excess liquids, filtering the waste or allowing the aqueous waste to evaporate in a fume hood. Dispose of liquids in the sanitary sewer or in an organic solvent collection carboy, as appropriate. Absorb any remaining liquids by adding absorbent (e.g., oil dry or absorbent paper).
- Any waste contaminated with a Toxicity Characteristic chemical must be given to the Safety Department following procedure **On-Site Service 1**. See ***Labware Contaminated With Chemicals*** for a list of the Toxicity Characteristic chemicals.
- For all other wet wastes or chemicals, call the Safety Department for advice, or dispose of the waste following procedure ***On-Site Service 1***.

### ⏭ Unknowns

Analysis and disposal of material for which the identity is not known can be expensive, from $30 to $1500 per unknown. The following steps will aid in the disposal of unknown materials generated on campus:

1. Consult with other workers in the area who may have an idea as to the identity of the material. Even a general chemical classification (such as aromatic sulfur compounds) can be very helpful. A phone call to a colleague who has left will pay for itself. To prevent unknowns, remember to label all your containers. When scientists plan to leave the university, contact Safety to help you clean out the laboratory so that unknowns can be identified.
2. Dispose of the material following procedure ***On-Site Service 3***.

## 7.2 On-Site Hazardous Materials Management Service

Surplus chemicals, waste organic solvents, most waste chemicals and some contaminated labware can be removed from your laboratory by the Safety Department's ***On-Site Hazardous Material Management Service*** (OSHMM).

### 7.2.a Disposal of Chemical Waste at UW-Madison

Hazardous waste disposal costs more than $200,000 each year at the UW.

**Where does it go?** When the Safety Department removes chemicals from your laboratory, it is first brought to a campus storage facility. There, the chemicals are sorted into several routes: on-campus redistribution, neutralization, chemical treatment, recycling, etc. Chemical waste that cannot be managed on campus is shipped out of state for incineration in a commercial hazardous waste incinerator or cement kiln. Waste containing toxic metals is shipped to a facility to recover the metal or to encapsulate the waste.

**What happens to it?** Incineration of hazardous chemical waste is required by law to achieve a 99.99% destruction efficiency and many chemicals are destroyed at even greater efficiency. Toxic metals are removed from the exhaust gases and remain in the ash. Although incineration is a superior method of hazardous waste disposal, all incinerators emit carbon dioxide (a global greenhouse gas) and other products of combustion, some of which may be toxic. No disposal method is without risk.

**Protecting the Environment.** No laboratory chemicals or chemical wastes may be disposed of in any campus incinerator. Campus incinerators do not meet the destruction standards for chemical waste, and are not permitted for chemical waste disposal.

Appendix A of this *Guide* lists those organic solvents that are to be collected in carboys for incineration via the Safety Department's On-Site Service. Many of those chemicals not listed in Appendix A (to be disposed of by On-Site Service) will also be disposed of at a commercial hazardous waste facility. This section describes procedures you should use for on-site removal of your waste by the Safety Department.

**Call us if you have questions.** Please call the Safety Department if you have a waste not covered in this guide, or if you have questions about On-site Service for removal of your chemical wastes.

### 7.2.b General Guidelines for Using OSHMM

This service is only for the removal of surplus chemicals and chemical wastes. For disposal of:

- radioactive waste, see Section XIX of the UW-Madison *Radiation Safety Guide*.
- animal tissue, carcasses and bedding, see Chapter 8 of this *Guide.*
- sharps (needles, pipettes and broken glass), see Chapter 9 of this *Guide.*
- biohazardous (infectious) waste, see *Guidelines for Handling Pathogenic Microorganisms*, from the UW Biological Safety Office.

Many chemicals can be managed in your laboratory. Before using one of the procedures below, look up your chemical or waste in Appendix A. In the preceding pages of this chapter is an alphabetical list detailing the disposal procedures that Appendix A lists by chemical. For all procedures, please follow these general guidelines:

- For chemicals or wastes not listed in Appendix A or not described in the preceding pages, call the Safety Department for removal. We will schedule a date and time to meet you.
- Prior to visit by the Safety Department, describe the chemical or waste on a Surplus Chemicals Form. Many department offices and stock rooms have these forms. The Safety Department will mail them to you upon request, or download them at http://www.fpm.wisc.edu/chemsafety/forms.htm.
- Safety Department staff will meet you to remove your chemicals; do not bring chemicals to the loading dock.
- Never leave chemicals or waste in a hallway.
- Solvent collection containers (carboys) are supplied by the Safety Department. You should supply all other containers according to the specifications below. Empty containers in which the chemicals are supplied are usually satisfactory for collection.

Do not leave waste chemicals on loading docks.

**SURPLUS CHEMICALS FORM**

1. This form is intended for disposal of surplus or unwanted laboratory chemicals. The UW tries to recycle as much as possible and your waste may be used by others. To dispose of waste solvents in carboys, please use the green "Chemical Inventory Analysis for Waste Solvents in Carboys" form.
2. You can safely manage many chemicals (e.g., acids, ethidium brroide solutions, simple salts, etc.) in your laboratory. Refer to Chapter 7 of the Chemical Safety and Disposal Guide for further instructions.
3. Please complete this form legibly, printing is preferred. An example is provided on the reverse of this form.
4. Please estimate the total weight of each container and its contents (gross weight) in pounds. Containers less than 0.1 pound should be entered as 0.1 pound.
5. Use additional sheets as necessary
6. When you have surplus chemicals for pickup, send us an eMail via our web page (http://www.fpm.wisc.edu/chemsafety/oshmm.htm) or call the Safety Department at 262-8769. You will need to give your name, phone number, building, room number and a brief description of the chemicals you have for pickup.
7. Packaging surplus chemicals is no longer necessary; our staff will come to your room and remove your surplus chemicals and carboys. We will also drop off empty carboys at this time.

| NAME | ROOM NUMBER / BUILDING | TELEPHONE NUMBER | DATE |
|---|---|---|---|
| FACULTY MEMBER | DEPARTMENT | | |

| HOW MANY? | CHEMICAL NAME OR DESCRIPTION (ESTIMATE CONCENTRATION IF SOLUTION OR CONTAMINATED LABWARE IN % PPM OR PPB) PLEASE PRINT | CHEMICAL TYPE LIQUID, SOLID, ORGANIC SOLUTION, AQUEOUS SOLUTION, CONTAMINATED LABWARE, GAS CYLINDER | TOTAL WT. OF CONTAINER IN POUNDS (0.1 LB MIN UNIT) |
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UW-Madison Safety Department 262-8769 -- **http://www.fpm.wisc.edu/safety**

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Call us if you have questions or problems. This service is available at no cost to UW-Madison faculty, staff and students. We encourage you to minimize the amount of chemicals in storage by promptly calling us to remove surplus or waste chemicals.

The Safety Department's On-Site Hazardous Materials Management (OSHMM) Service can be arranged by following one of the procedures described below, depending on the type of chemical or waste you wish removed. For removal of:

- Carboys containing organic solvents, follow procedure ***On-Site Service 2***, below.
- Potential explosives, gas cylinders or unknowns, follow procedure ***On-Site Service 3***, below.
- Unwanted, surplus or waste laboratory chemicals, follow procedure ***On-Site Service 1***, below.
- More than twenty (20) items of unwanted, surplus or waste laboratory chemicals, follow procedure ***On-Site Service 4***, below.

⏭ **On-Site Service 1:** Removal of surplus chemicals and chemical wastes

Call the Safety Department to schedule a visit for the removal of surplus chemicals and chemical wastes from your room. Prior to our visit, complete a "Surplus Chemicals" form, which are available from the Safety Department and many department offices and stockrooms. Use additional forms if necessary.

For sample collections of synthesis intermediates, extracted substances and collections of chemically similar materials of great variety and small amounts (i.e., dyes and stains), keep these together, well capped vials placed upright in a box, **not** as a pile in a bucket or in a sharps container. This is the best way to be able to

present the collection to the people who receive chemicals for ultimate disposal without having to write down each and every name (e.g., they can be named as a group). With chemicals produced in a combinational array, this will be helpful as well; keep similar series of different variants together as a neatly arranged group in a box.

Labeling lab generated waste material as “Solid Waste” is not really helpful; we can observe both that it is solid (or not) and that no one wants it. What is needed is the hazardous ingredient (i.e., the reason it is hazardous and not just laboratory trash) and any other major components.

You can arrange for delivery of empty carboys when you call. Waste organic solvents should be disposed of in carboys according to ***Organic Solvent Collection*** (above) and ***On-Site Service 2*** (below).

**Marking of Containers.** All containers must be marked legibly with the chemical's identity. See ***On-Site Service 3,*** below, for unknowns.

**Suitable Containers.** Chemical mixtures, aqueous solutions, other liquids and reaction products should be placed in a suitable container. Empty containers in which the chemicals are supplied are usually satisfactory for removal. Make sure all containers are tightly closed and contain the material that they hold. Please consider whether a waste reaction mixture or cleaning solution is done reacting and no longer producing a gas like nitrogen, carbon dioxide, hydrogen, oxygen or hydrogen chloride. Please be aware that “Pirahna Acid” cleaners for silicon chip work that use hydrogen peroxide and a strong acid (usually sulfuric), must **NOT** be made using hydrochloric acid -- specifically because hydrogen peroxide will oxidize chloride under acidic conditions to chlorine gas! It will oxidize hydrobromic and hydroiodic even easier, but that will be immediately obvious. Remember that hydrofluoric acid, even in low concentrations, will produce silicon tetrafluoride gas from glass. We cannot accept leaking containers. Each container must be less than 5 gallons.

- Suitable containers for **liquids** include glass bottles with their original screw caps. Plastic milk jugs are **not** suitable for waste collection.
- A variety of containers are suitable for **solids**, the container must be sturdy, rigid, able to be tightly closed so that the product is well-contained. Glass bottles with screw caps work well. Open beakers or flasks are not suitable.
- A suitable container for **contaminated labware** is a tightly closed plastic bag (folding the bag and taping it works well) inside a cardboard box. Clearly mark the outside of the box with its contents.
- Suitable containers for **wet solids** include (for small amounts) glass bottles with screw caps and (for larger amounts) tightly closed plastic bags (folding the bag and taping it works well) inside cardboard boxes. Clearly mark the outside of the box with its contents. No free liquid should be present with wet solid wastes; absorb any free liquid with absorbent paper or oil dry (do not use vermiculite for an absorbent).

See ***On-Site Service 4***, below, for removal of more than twenty (20) items.

### ⏭ On-Site Service 2: Waste solvent carboy removal and delivery

See ***Organic Solvent Collection*** for procedures on disposing of waste solvents.

See **Organic Solvent Collection** for carboy procedures.

**Removal of carboys of waste solvents.** Call the Safety Department to schedule the removal of waste solvent carboys from your room. Prior to our visit, complete a green "Waste Analysis for Carboys" form, which are available from the Safety

Department and many department offices and stockrooms. See ***Organic Solvent Collection*** for more information on completing the form. You can arrange for delivery of empty carboys when you call.

**Delivery of empty solvent collection carboys.** Carboys for waste solvent collection can be obtained by calling our office; we will schedule a delivery. Some stockrooms also have empty carboys. When reserving carboys, specify the type and number that you need. The new carboy types are both "square" in shape, the halogenated one is **yellow** and the non-halogenated one is **white**.

⏭ **On-Site Service 3:** Evaluation of gas cylinders, unknowns and potential explosives

For evaluation of gas cylinders, unknowns and material that you suspect may be explosive, call the Safety Department. We will visit your laboratory to evaluate the material and determine the most appropriate disposal route.

⏭ **On-Site Service 4:** Laboratory and stockroom clean-outs

We encourage you to regularly review your chemical stocks and dispose of any unwanted chemicals. For large cleanouts, it is most efficient if we can process and sort most of the chemicals directly in your laboratory or stockroom. This also minimizes the risk of transporting chemicals.

Safe chemical management takes time.

**Our role.** Clean-outs work best when the Safety Department and the lab work together. We will:

- remove chemicals that can be used by others on campus.
- advise you on neutralization of strong acids and bases and other treatment procedures.
- help you sort the remaining chemicals by disposal route.

**Your role.** If you plan to move from a lab, please call us two weeks in advance of your move so that we can help you clean out any surplus chemicals and wastes. We will need:

- to use your sinks and some space in your fume hood.
- help in locating empty containers, boxes and carts.
- equipment and materials for neutralizations and treatments.
- the guidance of someone who works in your lab to evaluate and identify samples, experimental products, unknowns, gas cylinders and older chemicals.
- someone from your lab to complete our disposal forms and other assistance.

This procedure is also appropriate for those labs that have been vacated and a large amount of chemicals have been left. For cleanouts of a small number of chemicals, use procedure ***On-Site Service 1,*** above.

## 7.3 Review Questions

1. To dispose of an unusable bottle of barium sulfate you refer to Appendix A and:
   a. Normal trash disposal is OK.
   b. Discharge it to the sanitary sewer.
   c. Set aside for the Safety Department's On-Site Hazardous Materials Management service.
   d. Give to another lab for reuse.

2. Waste chemical solutions poured down your laboratory sink go:
   a. Into a reservoir under the building.
   b. Into a storm sewer that leads to the lake.
   c. Via the sanitary sewer to the Madison Metropolitan Sewerage District's Treatment Plant.
   d. To the University's wastewater treatment plant.

3. Which of these bases is not suitable for the neutralization of perchloric acid:
   a. Potassium hydroxide.
   b. Sodium hydroxide.
   c. Magnesium hydroxide.
   d. Ethylenediamine.

4. Which of the following personal protective equipment should be worn while neutralizing waste acid or base solutions:
   a. Chemical splash goggles that form a seal against your face all around your eyes
   b. A full-length (neck to ankles), vinyl or rubberized apron.
   c. Heavy-duty acid-resistant gloves.
   d. All of the above.

5. Your calculator batteries need to be replaced. The label indicates that they are mercury cells. What would be the correct disposal method for them?
   a. Overpack them in a box and place it in the normal trash.
   b. Call for collection by the Safety Department.
   c. Break the case, recover the mercury and place the rest in the normal trash.
   d. Normal trash is satisfactory.

6. The five-gallon carboys that Safety provides for campus laboratories are used to dispose:
   a. Phosphate buffer solutions.
   b. Collection of waste organic solvents and their solutes produced in your lab.
   c. Aqueous heavy metal solutions.
   d. Anything that you should not pour down the drain.

7. Used vacuum pump oil should be:
   a. Discharged in a floor drain.
   b. Set on the loading dock.
   c. Poured into a solvent collection carboy.
   d. Collected in a non-leaking container, labeled properly and disposed of following procedure On-Site Service 1.

8. After running a chloroform / methylene chloride extract through a silica gel column, you should:
   a. Double-bag the silica gel and place in the normal trash.
   b. Spread it out in the hood to evaporate the solvent, then dispose of the dry powder in the trash.
   c. Bag or otherwise contain the wet gel and dispose following procedure On-Site Service 1.
   d. Empty the column into a carboy because it contains solvents.

9. If you break your mercury thermometer, you should:
   a. Recover or pick up the escaped mercury and store in a airtight container for disposal.
   b. Dispose of it in the normal trash.
   c. Replace it with an alcohol thermometer.
   d. a and c.

10. A 15-pound voltage regulator is found in the back of a stockroom. The instrument it originally part of was replaced in 1978. What is the primary concern with disposal of this item?
    a. It may contain PCBs. Contact the Safety Department for evaluation.
    b. There may be asbestos insulation on the wiring.
    c. Nothing; storage of electrical equipment is not regulated.
    d. The equipment's wiring may contain large quantities of mercury.

11. Needles and other sharps should be disposed of:
    a. In the normal trash.
    b. In special sharps containers as described in Chapter 9.
    c. Autoclaved, then thrown in normal trash.
    d. Double box before placing in the normal trash.

12. Aerosol cans can be sprayed out until empty and disposed of in the normal trash.
    a. True. b. False.

13. Appendix A is an alphabetic listing of:
    a. all the chemicals used at the UW.
    b. appropriate disposal procedures for waste laboratory chemicals.
    c. a random listing of chemical disposal procedures not found in Chapter 7.
    d. a list of chemicals to be picked-up via the On-Site Service.

14. Do not dispose of any mercury containing waste in the normal trash or sanitary sewer.
    a. True. b. False.

15. Which of the listed acids is so reactive and only slowly soluble in water that the Safety Department recommends labs **not to** neutralize.
    a. Concentrated hydrochloric acid.
    b. Sulfuric acid.
    c. Fuming nitric acid.
    d. Sodium carbonate.

16. Yellow, square carboys are used for organic solvent wastes that contain halogenated flammable solvents.
    a. True. b. False.