Part F: Pollution Prevention and Waste Minimization

Laboratories create pollution by making hazardous waste, by allowing organic solvents to evaporate, and by discharging certain hazardous materials down the drain. This Part will help you minimize the environmental impact of your laboratory operations. Part G of this Guide describes safe disposal methods for laboratory chemicals.

It may be difficult for your laboratory to minimize its waste. By its very nature, research is often the process of studying something and throwing it away. Unlike larger industrial processes, the multitude of irregular laboratory operations are intrinsically more difficult to control. Still, there are many things you can do to prevent pollution and minimize hazardous waste.

Once you have done what you can to prevent pollution, try to reduce environmental risks in other ways and follow those practices that have the least impact on the environment.

> The methods in this Part not only prevent pollution, but can also reduce the risk of chemical exposure and accidents.

PREVENT POLLUTION

A variety of methods can be used to prevent polluting the air, water, and land. There are two categories of pollution prevention: methods that reduce pollution at the source (the laboratory) and environmentally sound recycling. This Part only addresses methods to prevent pollution caused by hazardous chemicals.

Air and water pollution cost health and the environment in indirect ways. Hazardous waste disposal costs UWL directly. Not including labor and operating costs, UWL spends thousands of dollars annually to safely and legally dispose of chemical waste commercially.

> EPA defines *pollution prevention* as source reduction and environmentally sound recycling.

REDUCE POLLUTION AT ITS SOURCE

Changing practices and processes to prevent pollution at its source is referred to as *source reduction.* Source reduction methods include process modification, improved operation, and material substitution. Some businesses can prevent pollution by modifying their product, but this method is not as applicable at an educational institution.

> *Source reduction* includes modifying processes, improving operations, material substitution, and product modification.

Modify Laboratory Processes

Pollution can be prevented by changing the laboratory process by which the pollution is created. Modern extraction techniques (such as those that use a solid phase or supercritical fluid) minimize waste by using much smaller volumes of organic solvents. Computer simulations and modeling eliminate all environmental impacts when they are substituted for wet laboratory experiments. In the classroom, computer and multimedia simulations often allow students to observe more complex procedures than would be available by a traditional laboratory exercise.

Reduce the Scale of Laboratory Processes

One of the most successful pollution prevention modifications is reducing the scale of laboratory procedures. Innovative laboratory glassware and microscale techniques are now available that reduce quantities used to milligrams. Reducing the scale of laboratory processes not only prevents pollution, but also has many other benefits:

- Small scale experiments cost less because they use less chemicals; valuable raw materials are also conserved
- Small scale experiments usually run more quickly
- Heating and cooling is easier with smaller volumes
- Your exposure to chemicals is reduced
- The amount of fugitive emissions (evaporative losses) will be reduced

Improve Laboratory Operations

Pollution can be prevented by improving laboratory operations. Creative thinking can help you redesign laboratory procedures to use less chemicals, create less waste, prevent fugitive emissions and minimize unnecessary discharges to the sanitary sewer.

Careful and neat operations reduce waste. Take care when weighing or transferring chemicals between containers to minimize spills. Do not take fume hood emissions, sewer effluents or chemical wastes for granted. They are necessary for the safe use of laboratory chemicals, but chemical releases and disposal affect the environment, and should be minimized when practical. When it can be done safely, seal and contain processes to prevent the escape of fumes or leaks to the environment.

> Simple laboratory improvements can prevent pollution: minimize the amount of chemicals used, be neat when using chemicals, and keep volatile chemicals capped and sealed.

Less is Better

The American Chemical Society (ACS) urges scientists who work with chemicals to adopt the motto "Less is Better." It is safer and environmentally sound to buy less, store less, use less, and

dispose of less. Less reduces risks to you and your colleagues. Less reduces the risk of an accident or fire. Less saves space and money. Less prevents pollution.

Less *is* better! Buying smaller amounts of laboratory chemicals means: fresher stocks, reduced exposures, reduced emissions, less surplus to dispose of, and fewer accidents.

- ***Buy less***. Purchase only the chemicals and amounts that you need in the immediate future. If you need only a small amount, ask another laboratory if you can borrow their stocks. There is no such thing as a "large economy size" of a laboratory chemical. A bulk quantity may appear to be economical, but the cost of disposing of the excess will negate any savings. Do not purchase chemicals speculatively. Some chemicals age and degrade more rapidly than others degrade, and become waste. Avoid end-of-budget-year buying sprees. Do not accept gifts or samples unless you plan to use them in the immediate future. Do not accept more than you need. These practices minimize chemical waste because some of UWL's hazardous waste is unwanted surplus chemicals. Unfortunately, because of unnecessary purchases, laboratory chemicals with factory seals are shipped to be incinerated or treated in an alternate manner each year.

- ***Store less***. Storing excess and duplicate chemicals risks a fire, spill or leak. Some chemicals become reactive or explosive with age. Fugitive emissions from stored chemicals can lead to a harmful exposure. Storage of surplus takes up valuable laboratory space. Excess stored chemicals exacerbate a spill, leak or release, and adds risks when responding to a fire. These are all good reasons to buy less, and good reasons to regularly review your laboratory chemical stocks and dispose of surplus. See procedure On-Site Service 4 in Part G of this Guide for how the Environmental Health and Safety office can help you with a laboratory cleanout.

- ***Use less***. *As* discussed above, using less chemicals is safer for you and the environment.

HELP REDISTRIBUTE SURPLUS LABORATORY CHEMICALS

The Environmental Health and Safety office encourages faculty and staff to provide unwanted chemicals to colleagues in their department or other College departments. Environmental Health and Safety also practices redistribution of unwanted chemicals campus wide. For example, numerous useable aerosol spray paint cans are provided to staff within Facilities Planning and Management for use as primers or paint. The surplus unwanted chemicals are delivered to your laboratory, at no cost to you. When a chemical is received for disposal, Environmental Health and Safety determines if someone else can use it. All redistributed chemicals are in their original manufacturer's container. In many cases, these surplus chemicals still have the manufacturer's seals.

The Environmental Health and Safety office redistributes surplus chemicals between laboratories and other campus operations.

Use Surplus Chemicals

There are several ways to obtain surplus chemicals. The most efficient method is to discuss transfer of the chemical directly among Department or College colleagues. You oftentimes may know who may need a chemical you no longer desire to retain.

Redistribute Your Surplus Chemicals

Redistribution works with chemicals that have not degraded with age. So, please review your chemical inventory regularly and give your surplus chemicals to the Environmental Health and Safety office or your colleagues. This will make your surplus chemicals available for use by other laboratories. See procedure On-Site Service 1 in Part G of this Guide for removal of surplus chemicals.

A Success Story

The Environmental Health and Safety office laboratory chemical redistribution program has been in existence since 1993. We have redistributed thousands of pounds of chemicals. Saving UWL tens of thousands of dollars.

You receive free laboratory chemicals. We reduce the amount of chemical waste that needs to be disposed. The whole University benefits!

CONTROL YOUR LABORATORY CHEMICAL INVENTORY

As described above, a significant amount of laboratory hazardous waste is the result of disorderly chemical inventory practices. Duplicates are purchased because chemicals are not stored carefully and records of the current inventory do not exist. Labels fall off older containers, which creates unknowns that are expensive to analyze and dispose. Because of careless use and inventories, scientists are reluctant to share chemicals, so laboratory shelves often hold half-filled bottles that will eventually be disposed of as hazardous waste. Worse yet, some chemicals become unstable, reactive, or explosive with age. If you are not monitoring expiration dates and chemical stocks, your safety is at risk.

Many vendors sell laboratory chemical inventory software.

You can end these problems by controlling your laboratory's chemical inventory. Keep an inventory of your laboratory chemicals in a file or database. This works best when:

- Put one or two people in charge of purchasing new chemicals and maintaining the inventory.
- Mark or code chemical containers to correspond to an identifier in the database; also, date each incoming container.
- Because of their small size and great number, samples are usually omitted from the inventory (however, make sure samples are marked properly).
- To keep the system manageable, some laboratories do not inventory containers smaller than 100 grams unless highly reactive, toxic or valuable.
- Devise a system of identifying chemical storage areas in your laboratory and mark them; include this location in the database or file.
- Rotate stock; follow the principle of first-in, first-out.
- Keep track of expiration dates and storage times, especially for peroxide-former and other degradable chemicals; see the Precautions for Peroxide-Forming Chemicals section in Part D of this Guide.
- Keep track of emptied containers and waste disposal to remove chemicals from the database or file.

See the Chemical Storage and Management section in Part D for chemical labeling guidelines.

Where Does It Go?

You purchase and use laboratory chemicals, but where do they go? Part G of this Guide describes chemical disposal procedures, and what happens to waste that is disposed in the sanitary sewer or given to Environmental Health and Safety. If you add up all your chemical purchases, and subtracted all the waste you give to Environmental Health and Safety, chances are good that a variance exists.

The best way to assess your laboratory's impact on the environment is to conduct a *mass balance.* Choose one chemical, such as an organic solvent, and account for purchases and disposal. Then try to determine where the rest goes.

Stored solvents can evaporate, be emitted to the air, and may contribute to air pollution. Poorly capped volatile organic solvents stored in a fume hood can disappear overnight. Does yours? A rotary evaporator will draw solvents into the sanitary sewer. You start your procedure with a certain amount of solvent. How much of it ends up in the waste solvent carboy?

A chemical *mass balance* is the first step in assessing your lab's impact on the environment.

REDUCE LABORATORY AIR EMISSIONS

One potential source of pollution from laboratories is the emission of volatile chemicals into the air. To prevent chemical exposure to personnel, laboratories are designed to include fume hoods, local ventilation, ventilated cabinets, and room ventilation. The exhaust of these systems are not filtered or controlled for volatile chemicals, fumes, or gases. As a result, you should use these ventilation systems to protect you from chemical exposure, but use them prudently to prevent excessive emission of laboratory chemicals. Evaporation of laboratory organic solvents contributes to UWL's air emissions.

To reduce air emissions, keep containers of volatile chemicals closed. Wasteful energy use also results in unnecessary pollution. Turn equipment off and keep lab hood sashes closed when not in use. Your efforts to conserve energy prevent pollution.

Simple laboratory practices can minimize air emissions:

- Keep containers of volatile chemicals capped; if a cap is not tight, replace the cap or transfer the contents to another container.
- The best container seals have an even rim on the bottle and an appropriate fitting cap with polyethylene or Teflon liner.
- Minimize the amount of volatile chemicals in your lab; order and store only what you need in the immediate future; redistribute your surplus chemicals.
- Do not store chemicals in the fume hood; use a ventilated cabinet, which has only a slight negative pressure and is less likely to draw volatiles into the air.
- Keep laboratory processes involving volatile chemicals as closed to atmosphere as safely possible.
- Consider performing procedures in a glove box instead of a fume hood; glove boxes are more effective in the prevention of exposure and minimize fugitive emissions.
- Keep waste solvent collection containers capped at all times, unless you are adding waste.
- To minimize the amount of waste solvents in your lab, routinely dispose of containers through your department stockroom or by contacting Environmental Health and Safety.

At a minimum, contact Environmental Health and Safety for container disposal within three days of being filled (see procedure On-Site Service 2 in Part G of this Guide*)*.

- Do not dispose of any chemical by evaporation; it is illegal to evaporate hazardous chemical waste for the purpose of disposal.
- Do not dispose of any gas by venting unless told to do so in Part G or by the Environmental Health and Safety office.

Do not dispose of any chemical by evaporation.

REDUCE LABORATORY WASTEWATER EFFLUENTS

As long as you use a sanitary sewer and follow the Sanitary Sewer Procedures in Part G and Appendix A of this Guide*,* you may safely dispose of a variety of laboratory wastes down the drain. Just remember:

- Make sure containers of liquids are not leaking.
- Make sure wastewater drainpipes within your lab do not leak.
- Work with others in your lab to limit sewer discharges to those in Part G of this Guide.
- Do not dispose of any waste into a storm sewer; most outside drains and sewers are storm sewers that discharge directly or indirectly into the river.
- For wastes that are disposed of in the sewer, consider less toxic substitutes.

When a process is connected to a water supply, the water supply must have an anti-siphon or backflow prevention device to prevent contaminants from being drawn into the potable water supply.

SUBSTITUTE WITH A SAFER CHEMICAL

One of the most successful ways to prevent pollution is by substituting a hazardous chemical with a less hazardous chemical. For many laboratory methods, an environmentally sound alternative exists.

Search for a safer substitute. Let us know if you find ones not mentioned here.

Use Non-ignitable Liquid Scintillation Cocktail

One of UWL's successful pollution prevention practices is substitution of non-ignitable liquid scintillation cocktail (LSC) for toluene-based cocktails. This reduces the risk of laboratory fire and personnel exposure to toluene. Toluene-based cocktails must be incinerated as a hazardous waste. Most non-ignitable, water emulsifiable LSC can safely be disposed of in the sanitary sewer.

We have learned much about toxicity in recent years. Substitution with a safer chemical is one of the best ways to prevent pollution. However, substitution is not always ideal. Some procedures do not work as well. Some substitutes are not as safe as you would like. Substitution often requires successive trials and evaluations.

Other Substitutes

In a landmark study, the Division of Environmental Health and Safety of the University of Illinois at Urbana-Champaign, explored laboratory waste minimization opportunities. (Ashbrook, Peter C., Cynthia Klein-Banay and Chuck Maier, *Determination, Implementation and Evaluation of Laboratory Waste Minimization Opportunities, 1992.)* The following table includes some common chemical substitutes from that study.

Hazardous Chemical	Safer Substitute	Used For
Acetamide	Stearic Acid	Freezing point depression
Benzene	Xylene or hexane	Many solvent uses
Benzoyl Peroxide	Lauryl Peroxide	Some polymer Catalysis
Carbon Tetrachloride	Cyclohexane	Qualitative test for halides
Formaldehyde (Formalin)	Ethanol	Specimen storage
Halogenated Solvents	Non-halogenated solvents	Some extractions and other solvent uses
Sodium Dichromate	Sodium Hypochlorite	Some oxidation reactions
Sulfide ion	Hydroxide ion	Qualitative test for heavy metals
Toluene-based Scintillation Cocktail	Non-ignitable Scintillation Cocktail	Studies using radioactive materials

Stop Using Chromic Add Solution

Chromic acid solution is a mixture of concentrated sulfuric acid and potassium dichromate, Chromerge (chromic acid), or chromium anhydride (chromium trioxide). It is used to clean laboratory glassware because it oxidizes most residues and eats away a very thin layer of the glass surface, leaving a new, clean surface.

Chromic acid solution is a dangerous chemical. It is a strong corrosive. It is also a strong oxidizer known to react violently and explode when combined with oxidizable materials. It contains chromium (VI) (as chromic or dichromic acid), which is a known human carcinogen. Chromium is toxic in other ways to humans, flora and fauna. These properties make it extremely difficult to handle safely.

> Chromic acid solution is a strongly oxidizing corrosive that contains a carcinogen. Stop using chromic acid solution unless you have tried the alternatives and found them to be unsatisfactory.

There are many commercially available alternatives for chromic acid solutions. Environmental Health and Safety office strongly encourages you to stop using chromic acid solutions unless you have tried the below alternatives and found them to be unsatisfactory. They are listed in groups of increasing hazard. This information is derived from the University of Illinois study.

Nonhazardous cleaning solutions (safest; try these first)

- Ultrasonic baths (these work well for many labs)
- Alconox or similar detergents
- Pierce RBS-35 or similar detergents
- Biodegradable surfactants.

Strong corrosive solutions (hazardous due their corrosivity)

- Potassium hydroxide/ethanol solutions (also flammable)
- Dilute hydrochloric acid

Strong oxidizing acid solutions not containing chromium or other toxic metals (very hazardous; least desirable alternative). Other solutions of strongly oxidizing acids work in the same way as chromic acid solution. Potassium permanganate/sulfuric acid baths are generally not recommended: they are very dangerous and potentially explosive if made incorrectly.

- Potassium persulfate/sulfuric acid (sold commercially as No-Chromix®)
- Aqua regia (mixture of hydrochloric and nitric acids)

Avoid Mercury and Its Compounds

Like chromium, mercury is a toxic metal that cannot be neutralized (as corrosives can) or destroyed (as organics can). As a result, mercury is very difficult to dispose.

Mercury and its compounds are still used in laboratories. Mercury waste from broken thermometers was once common at UWL. However, most mercury containing thermometers have been replaced with mercury free thermometers. When replacing thermometers or any other equipment, go mercury free whenever possible! Although free-flowing metallic mercury can be recycled commercially for reuse, mercury contaminated thermometers and spill cleanup supplies are expensive wastes.

Anyone who has broken a mercury thermometer or spilled free-flowing mercury knows how difficult and time consuming it can be to clean up the residue. In the extreme case, residual mercury from a spill or careless handling can pose a chronic health risk to laboratory personnel.

To prevent these problems, Environmental Health and Safety strongly recommends that you use alternatives to mercury thermometers. These include alcohol (red liquid) thermometers, thermocouples, and other electronic temperature devices.

Replace mercury thermometers with mercury-free thermometers.

Thermocouples are preferred for monitoring the temperature of a water bath, where glass thermometers are prone to breakage. If alcohol thermometers and thermocouples are unsatisfactory, we recommend using Teflon© coated thermometers that will contain the mercury in the event that the capillary is broken.

Due to their toxicity, mercury compounds and solutions containing mercury must be carefully stored and used. Laboratories are encouraged to reduce the amount of mercury they use and mercury-containing wastes they generate. Several alternatives exist:

- If a mercury compound is specified for a procedure, first determine if a less toxic substitute can be used; for example, in most cases copper sulfate can be substituted as the catalyst in Kjeldahl analyses with no loss in total organic nitrogen recovery.
- Reduce the scale of the process to reduce the amount of mercury used and disposed.
- Minimize the volume of waste generated by including precipitation or other treatment methods as the last step. Only buy as much mercury and mercury compounds as you will use in the immediate future.

See Part D of this Guide for details on mercury spill cleanups. Part G describes mercury disposal procedures.

ENVIRONMENTALLY SOUND RECYCLING

Recycling is the processing of waste so that it can be used again. Recycling should be done in a way that does not harm the environment. For example, distillation of waste organic solvents requires containment to prevent spills and leaks. Controls may be necessary to minimize air

emissions and prevent exposure to laboratory personnel. Transport and handling risks are minimized when recycling occurs as part of the laboratory process (in-process recycling) or near to the point of waste generation (in the lab or building).

Distill Waste Organic Solvents

In-laboratory distillation can be used in the laboratories at UWL to recycle waste organic solvents. For instance, laboratories could recover xylene for reuse in tissue preparation; many histology laboratories successfully recycle their solvents. Recovered acetone and ethanol can be used for rinsing glassware, where technical grade quality solvents are satisfactory. The University of Illinois study and other laboratories have found that many other waste streams could be successfully recycled, including methanol/laser dye mixtures and acetonitrile waste from HPLC analysis. Call Environmental Health and Safety if you would like to explore solvent distillation.

Because waste organic solvents are such a large wastestream in many labs, distillation and reuse has great potential for preventing pollution.

Commercial Recycling of Laboratory Chemicals

The Environmental Health and Safety office actively recycles metallic mercury, petroleum-based oils from diffusion and vacuum pumps, and uncontaminated lead. You may give these wastes to Environmental Health and Safety by following procedure On-Site Service 1 in Part G of this Guide.

The small scale of lab waste, the lack of markets for recycled waste, and the unavailability of environmentally sound recycling facilities limits commercial recycling of laboratory chemicals and wastes.

MINIMIZE WASTE

Beyond pollution prevention, hazardous chemical waste can be minimized by reusing the waste in another process or by recovering its energy value. Beneficial reuse is exemplified when laboratories use surplus base to neutralize waste acids. This not only minimizes hazardous waste, but also creates a product that can be safely disposed of in the sanitary sewer.

Hazardous waste is minimized when organic solvents are disposed of in a waste collection container. Most waste organic solvents from UWL have a high BTU value and are excellent fuels. To recover their energy, waste solvents are blended with other fuels and used to produce cement or as a fuel at hazardous waste incinerators. Chemical destruction by this process is very efficient.

REDUCE ENVIRONMENTAL RISKS

In addition to pollution prevention and waste minimization, there are other things laboratories can do to reduce environmental risks. Wastes that are neutralized, treated, and managed in the laboratory are not subject to transportation and handling risks. Part G of this Guide encourages neutralization of acids and bases that are not contaminated with other toxic substances, such as silver, chromium, or lead.

The disposal method for the majority of non-solvent hazardous chemical waste generated at UWL is incineration. Incinerators reduce the environmental risks of hazardous waste by

destroying more than 99.99% of its organic constituents. Emissions are further reduced by pollution control equipment.

For those wastes that cannot be prevented or further minimized, incineration and fuel blending are environmentally sound chemical disposal methods.

Neutralize Waste Acids and Bases

Hazardous waste regulations allow laboratories to neutralize their waste acids and bases for disposal in the sanitary sewer. In-laboratory neutralization and sewer disposal can be done safely and is very efficient. Only neutralize and dispose of acids and bases if the waste has no other hazardous characteristics, for instance, silver, chromium, or lead. Contact Environmental Health and Safety to discuss conditions to disposal of neutralized acids and bases in a lab sink connected to a sanitary sewer drain.

See Part G of this Guide for several neutralization procedures. Appendix A lists neutralizable chemicals and their corresponding procedure in Part G.

MANAGE WASTE EFFICIENTLY

In some cases, waste can be minimized, but not eliminated. As mentioned at the beginning of this Part, waste is a natural product of research, teaching and testing. It is prudent to manage all remaining wastes as efficiently as possible. Resources saved from efficient waste management can be used to enhance safety and environmental protection projects.

The management of chemical waste is most efficient when laboratory personnel keep waste types separate, prudently use the sanitary sewer and normal trash, and help collect waste efficiently.

Keep Waste Types Separate

Do not mix different types of wastes except organic solvents that are collected in containers, as described in procedure Organic Solvent Collection in Part G of this Guide. When hazardous and nonhazardous wastes are mixed, the mixture becomes hazardous and the entire volume needs special disposal procedures. When wastes of different characteristics and compositions are mixed, treatment and disposal becomes much more difficult. For example, organic chemicals can be incinerated, but mercury waste that has been mixed with organic chemicals cannot be legally incinerated.

Keeping wastes separate maximizes disposal options and keeps disposal costs down. Also, keep radioactive, biohazardous, infectious, and chemical waste as separate as possible.

Most importantly:

- Do not place hazardous waste in the normal trash. Appendix A lists some chemicals that can safely be disposed of in the normal trash; follow Normal Trash Procedures in Part G of this Guide.
- Do not place normal trash (or wastes that can be disposed of in the normal trash or sanitary sewer) in containers of laboratory chemicals or chemical wastes.

Safely Use the Sanitary Sewer and Normal Trash

Many laboratory chemicals can safely be disposed of in the sanitary sewer or in the normal trash. Proper use of these methods prevents unnecessary handling of these wastes. Part G of this Guide includes specific procedures for using the sanitary sewer and the normal trash.

Minimize Chemically Contaminated Labware

One UWL waste stream is chemically contaminated labware. Procedure Labware Contaminated With Chemicals in Part G of this Guide describes how to dispose of this waste. There are several ways to reduce the volume of contaminated labware. First, discard only wastes known to be chemically contaminated as hazardous wastes. If your gloves and benchtop covers were not contaminated, dispose of them as normal trash. For contaminated labware, try to decontaminate it according to the procedures in Part G.

IS YOUR LABORATORY A GREEN LABORATORY?

A Green Laboratory is one that understands its impact on the environment and tries to minimize it. Since laboratory operations differ, there is no one standard for a Green Laboratory. The following actions, however, indicate that a laboratory is a leader in pursuing sound environmental practices. A Green Laboratory takes the following actions.

- Train new personnel in chemical and environmental safety, including methods of pollution prevention and waste minimization used in the laboratory.
- Assess laboratory air emissions, wastewater discharges, and waste generation to understand how its operations affects the environment.
- Buy only the chemicals and amounts needed.
- Use redistributed surplus chemicals whenever possible.
- Review chemical inventories and routinely provide usable surplus to Environmental Health and Safety or sharing directly with colleagues.
- Review the chemicals in use to understand their hazards (e.g., reading Safety Data Sheets) and search for safer substitutes.
- Keep caps on carboys and other containers of volatile chemicals.
- Prepare for leaks and spills by using secondary containment and by stocking spill control supplies.
- Take responsibility for waste disposal by neutralizing acids and treating other chemicals.
- Remind colleagues and new personnel to keep waste types separate, and devise a system of separate waste collection that works for their laboratory.

AN ENVIRONMENTAL ETHIC

Scientists who value the environment bring a special zeal to pollution prevention. In the laboratory, an environmental ethic means taking responsibility for the byproducts of research and teaching, and the generated waste. Scientists are creative by nature, and because they are most familiar with their work and the materials they use, they are the best source of new ideas to prevent pollution and minimize waste.

Contact Environmental Health and Safety if you have or ant to implement pollution prevention ideas. Successful pollution prevention initiatives will be shared with others.

REVIEW QUESTIONS

1. Which of the following is not a method of source reduction:
   a) Process modification
   b) Substitution
   c) Recycling
   d) Improved operation

2. A substitute for benzoyl peroxide for some polymer catalysis is:
   a) Cyclohexane
   b) Sodium hypochlorite
   c) Stearic acid
   d) Lauryl peroxide

3. Less toxic alternatives to chromic acid include:
   a) Detergents, ultrasonic baths and potassium permanganate baths
   b) Detergents, ultrasonic baths, lead chromate dissolved in sulfuric acid and biodegradable surfactants
   c) Detergents, ultrasonic baths, oxidizing agents not containing heavy metals and biodegradable surfactants
   d) Detergents, ultrasonic baths, bleach and biodegradable surfactants

4. Which of the following is not an alternative to an ordinary glass mercury thermometer?
   a) Alcohol (red liquid) thermometer
   b) Thermocouple
   c) Teflon coated mercury thermometer
   d) An incubator

5. Which of the following is not a method to reduce the risk involved in chemical use and management?
   a) Neutralization
   b) Chemical treatment
   c) Open burning
   d) Incineration

6. Items that cannot be disposed of safely in the normal trash include:
   a) A half-full bottle of barium carbonate
   b) Solvent-soaked silica gel
   c) Glassware containing mercury droplets
   d) All of the above

7. To reduce the volume of waste that is generated in your laboratory you can:
   a) Leave the cap off your carboy to evaporate solvents
   b) Neutralize acids and bases that do not contain silver, chromium, lead, or other hazardous waste constituents.
   c) Dispose of any quantity of chemical in the sanitary sewer
   d) Heat aqueous solutions until they are evaporated away

ANSWERS

1. c) Recycling

2. d) Lauryl peroxide

3. c) Detergents, ultrasonic baths, oxidizing agents not containing heavy metals and biodegradable surfactants

4. d) An incubator

5. c) Open burning

6. d) All of the above

7. b) Neutralize acids and bases that do not contain silver, chromium, lead, or other hazardous waste constituents.