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The Dangers and Handling of Hazardous Chemicals in the Geologic Laboratory

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By Alice Riedmiller, Phoebe L. Hauff,
and Richard W. Mathias

G E O L O G I C A L S U R V E Y C I R C U L A R 9 2 4

United States Department of the Interior
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INTRODUCTION

The safe control of hazardous chemical materials is based on knowledge of their physical properties and on the subsequent proper handling and storage of any dangerous materials. Several types of solvents and corrosive chemicals are used in the geologic laboratory as diluents, oxidants, and metal extractants. They are used for chemical analyses, sample digestion, rock decomposition, and etching.

Carelessness with or misuse of these chemicals can cause permanent damage not only to the laboratory and surrounding property, but also to the user and others as well.

The objective of this compilation is to provide basic information about the more common acids, bases, and solvents used regularly in geologic laboratories. The physical properties of each are itemized for quick reference. The toxicity and exposure symptoms, as well as the hazards involved in storage and handling, will be discussed for each chemical. All sections have been referenced so that the reader will have sources for additional information and for substances not included in this paper. Any use of trade and company names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

The authors would appreciate any comments and supplemental data from readers that would enhance this presentation.

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Denver, Colorado 80225

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INFORMATION SOURCES

Information sources are liberally referenced throughout the paper, especially where further details are needed. These are listed in the "References cited" section at the end of the paper.

However, general sections and philosophies that the authors present in this compilation are not so easily cited. Additionally, many things are not covered here that the reader may wish to learn about. Therefore a section containing other general references to chemical and laboratory safety information has been included.

TOXICITY AND GENERAL EFFECTS TO THE HUMAN BODY

Each chemical described in this paper is toxic and is explained relative to the immediate and long-term deleterious effects that exposure to these chemicals has on the human body. This section will discuss the exposure media that chemicals have to insult the body.

The *Threshold Limit Value* or TLV, is the total exposure to chemical vapors of a compound that

an average person can safely and repeatedly tolerate in an 8-hour work day and a 40-hour week. The Threshold Limit Value is a time-weighted concentration, and deviation above the stated limit is permissible, provided that equivalent exposures occur below this limit; however, any deviation should not exceed a stipulated ceiling value (Zenz, 1975).

"Because of wide variation in individual susceptibility, exposure of an occasional individual at or even below the threshold limit may not prevent discomfort, aggravation of a pre-existing condition, or occupational illness" (Zenz, 1975). Consequently, the TLV is meant only to provide guidelines for routine situations. It should not be used as a measure relative to abnormal working conditions, such as heavy physical work load, heat stress, overtime, or working with mixtures of chemicals (Zenz, 1975).

Skin contact is the most common means of body exposure to toxic substances. Direct damage to the skin may occur or the toxic substance may be absorbed through the skin, enter the bloodstream, and cause systemic poisoning.

Poisoning by ingestion is less common and usually occurs when small amounts of the residue of a toxic substance is taken into the body from hand, face, or clothing. The absorption of a toxic substance into the bloodstream is not always complete. It is affected by concentration, by the intake of food or liquids that causes dilution, by the natural tendency of the intestines to reject absorption of a foreign or harmful substance, and by the routing of toxic material to the liver where, if possible, it is altered and broken down. These diminution procedures unfortunately do not apply to substances that are extremely toxic (National Institute of Occupational Safety and Health (NIOSH), 1977).

Inhalation by the respiratory tract is probably the primary route for internal poisoning, and is a function of the surface area of the lungs and their capillary system. This large, interconnecting network allows for a rapid rate of absorption of any material reaching the lungs (NIOSH, 1977). Vapors of low water solubility but high fat solubility are absorbed through the lung and are redistributed to various organs for which these chemicals have an affinity. If not metabolized by the body, these chemicals can be cleared from the organs by the respiratory system (NIOSH, 1977).

External, reflexive responses of the respiratory

tract that may be an indication of exposure to irritant sources are sneezing, pain, cough, increased pulse or blood pressure, and rapid, shallow breathing, depressed breathing rate or cessation of respiration (Zenz, 1975). Aside from the direct or acute effects that exposure may produce, there are those secondary, indirect symptoms or chronic effects that may develop with time. This delayed reaction can happen through cumulative exposure to small amounts of a toxic chemical or by a delayed, metabolic reaction to a chemical after entry into the body (NIOSH, 1977).

GENERAL EMERGENCY PROCEDURES

There are several general emergency procedures that can be followed for all the various chemicals discussed in this paper. These procedures are outlined in this section. The more specific procedures are found in detail under each chemical.

FIRST AID TREATMENT

First aid treatment for skin or eye contact exposure to any of these chemicals is basically the same: flush the affected area with large volumes of water for at least 15 minutes. If the torso or legs are affected, use the overhead safety shower and remove any contaminated clothing. If the eyes are affected, the lids must be held open and the eyeballs rolled around while the entire optic area is rinsed by water from an eyewash station, under the shower, or by a hose attached to a cold or preferably a mixing faucet. Water is the universal diluent, but must be used in large volumes to be most effective. Emergency first aid treatments can require from 50-140 gallons of water, and showers can discharge 525 gallons when run at full flow for 15 minutes.

The extent of injury from chemical exposure is directly related to the lapse of time between exposure and flushing with water (N. V. Steere and R. Rodgers, oral commun., 1979).

Some sources suggest that a dilute solution of *boric acid* can be used as an eyewash for any materials other than corrosives. However, boric acid is not as effective as large volumes of water and possibly can cause undesired side effects.

Sodium bicarbonate is a good universal neutralizer for most acids and bases; however, the body is not the place to conduct chemical reactions. Additional injury can occur from the heat

of the reaction and the time lost in attempting to neutralize. Large volumes of water should be available and should be used to flush chemicals from the eyes or body. After the recommended 15 minutes flushing, mild soap and water can be used to remove any residual chemical, followed by a medical examination (N. V. Steere, oral commun., 1979).

FIRE

The safest first emergency procedure to follow in case of a fire is to trigger a fire alarm, if it is directly connected to the fire station, or to call the fire department *immediately*.

If the laboratory personnel have been trained in the use of fire extinguishers and if the fire is small, only then should an attempt be made to extinguish it. However, the fire department should always be notified first. A fire in a laboratory can escalate within seconds. The safest procedure is to get out of the laboratory immediately and wait for the professionals from the fire department. Some laboratory fire possibilities are illustrated in the U.S. Geological Survey laboratory safety videotape (Hauff and others, 1979). Never allow a person to work alone with flammable or explosive chemicals.

PROTECTIVE CLOTHING

Personal protective equipment should be worn at all times when handling toxic chemicals (fig. 1). Generally, this equipment would include gloves that are not dissolved by the solvent or corrosive compound, and a laboratory coat or apron that will not absorb the chemical or deteriorate upon prolonged contact. Obviously, concentrated corrosives will decompose just about any type of cloth they contact. Some plastics and rubber usually are resistant for a sufficient amount of time to save the body from direct contact with the hazardous material.

Goggles, face shield, or some type of safety eye protection are mandatory. The eyes are the most sensitive external part of the body to contact chemicals. Eyesight is an extremely fragile thing, and can be destroyed when subjected to the destructive capabilities of some of these corrosives.

Wearing of contact lenses in a laboratory environment has been a subject of controversy. One argument is that splashing chemicals or foreign

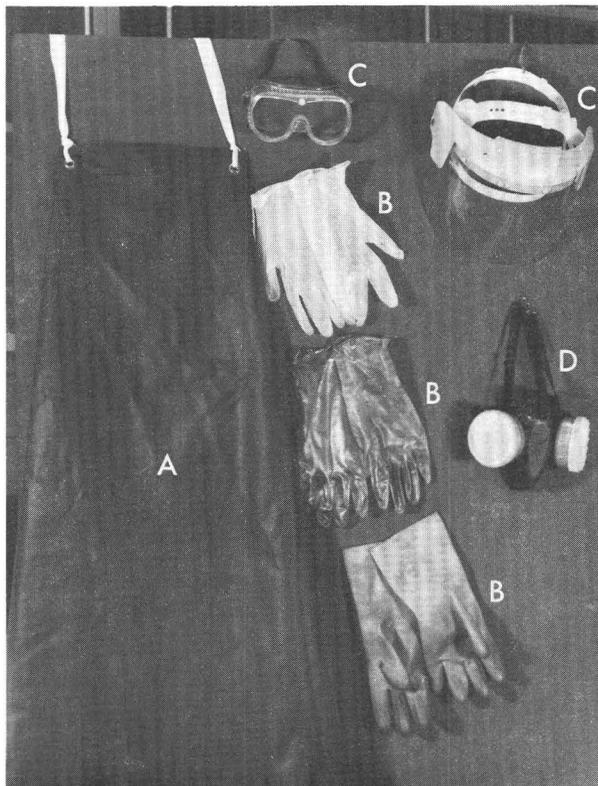


FIGURE 1.—Some personal protective equipment suggested for use in the laboratory. A, Rubber apron; B, various types of gloves; C, goggles; D, face shield; E, cartridge respirator. Photograph by Louise Hedricks.

particles could be trapped beneath the lens and injure the eye.

However, research done by Guthrie and Seitz (1975) at the Eastman Kodak Company on hard lenses suggests that under *certain circumstances* the contact lens can act as a barrier to a potential irritant and seal off the area under the lens. Their work was preliminary and probably should not be extrapolated beyond their test parameters.

Therefore, if hard contact lenses must be worn in a laboratory, supplemental eye protection should be worn also.

Soft lenses may be susceptible to some corrosive atmospheres and may dissolve with potential damage to the eye. Soft lenses also may become etched and ruined. Unfortunately, systematic studies have not been made to determine the solvents and corrosives that can interact with soft lenses (Bausch and Lomb, written commun., 1981).

Before wearing contact lenses in a laboratory, check with the prescribing optometrist and the manufacturer for the appropriate precautions.

Respiratory protection is suggested also, especially when handling some of the solvents that are suspected or known to be carcinogenic. Always use a fume hood when working with these chemicals. Be certain that the hood ventilation system is adequate. Most of the substances discussed here can be safely used in a hood that draws 125 feet per minute face velocity. This is usually optimum with the hood sash pulled a third to halfway down. Some people are overly sensitive to certain types of organic solvents, even when working in a properly venting hood. These people should have supplementary respiratory protection.

CLEANUP KITS

Cleanup kits should be available wherever spills of solvents or corrosives may occur. Most commercially packaged kits contain goggles, gloves, and

enough absorbent and (or) neutralizer to clean up a 1-pint spill.

The general procedure is to pour the absorbent onto the spill, mix it with the solvent, scoop up the mess, and dispose of it in a bag that should be labeled as to its contents. A small spill that has been completely neutralized probably can be disposed of safely in a large garbage pickup container. Call the fire department or appropriate comparable response group to assist in cleanup of high-volume spills.

Most acid-spill kits have an absorbent that also acts as a neutralizer. Some of the more concentrated, corrosive acids require a precipitating agent before the neutralizing absorbent can be applied.

Be certain that the correct type of spill kit is



FIGURE 2. A general laboratory safety station containing: standard, commercially-available acid, caustic, flammable, hydrofluoric acid, and mercury cleanup kits; glass-bottle safety carrier; goggles, safety glasses, and face shield; sodium bicarbonate; respirator; kaolin powder for heavy-liquid spills; and first-aid treatment materials. Photograph by Louise Hedricks.

used; that is, flammable for flammable solvents, acid for acids, and that the instructions are read before applying the contents to the spill.

Sodium bicarbonate also can be kept on hand as a quick neutralizer for both acid and base spills. Figure 2 shows a laboratory safety station. Some chemicals, such as mercury and hydrofluoric acid, require special cleanup and neutralizing procedures. If such a compound is used in the laboratory, be certain that the proper cleanup facilities exist for it.

WASTE DISPOSAL

Great care must be taken in disposing of hazardous chemical waste, and even neutralized waste from chemical spills.

The Environmental Protection Agency (EPA) has extensive regulations dealing with waste disposal. Many local, state, county, and city governments also have strict laws (Federal Register, 1980a,b).

To dispose of chemically generated waste materials "in the properly accepted fashion," we suggest that the laboratory supervisor be familiar with the regulations and that a licensed waste-disposal contractor be used. Some chemicals such as biodegradable solvents can still, when totally neutralized, be flushed down the drain. Halogenated compounds and heavy metals cannot. The regulations should be known and understood before any "informal" chemical waste disposal is undertaken.

Another helpful EPA publication deals with the compatibility of hazardous waste (Hatayama and others, 1980). Before hazardous chemical waste is transported there are numerous regulations that must be satisfied relative to packing and shipping. (See Code of Federal Regulations, 49 CFR 101.1, parts 100-177, other regulations relating to transportation, Revised Dec. 1, 1980, Office of the Federal Register, National Archives and Records).

GENERAL HANDLING AND STORAGE PROCEDURES

Many of the potential hazards involved with these chemicals can be reduced and eliminated if the chemicals are properly stored and handled.

Storerooms should be neat and orderly, with no accumulation of ignitable materials. Ventilation should circulate air efficiently through the entire room, removing flammable and corrosive vapors. Incompatible chemicals must be separated from

each other. The explosion or ignition potential obviously is increased with proximity if the containers break or corrode and the chemicals mix.

Bottles should be transported in special plastic or rubber carriers designed to cushion falls and to contain broken glass and liquids.

Grounding of metal containers is necessary when transferring solvents from one container to another. This grounding prevents a buildup of static electricity caused by the flow of the liquid and avoids subsequent possible ignition. Figure 3 shows an approved, grounded safety can for solvent storage.

All containers should be labeled as to the identity and hazard of the chemical within them. There are several standard labeling systems available (Meyer, 1977). Figure 4 illustrates some common labeling terms and symbols. The labels should be read before using a chemical. Major chemical companies provide detailed information on the label

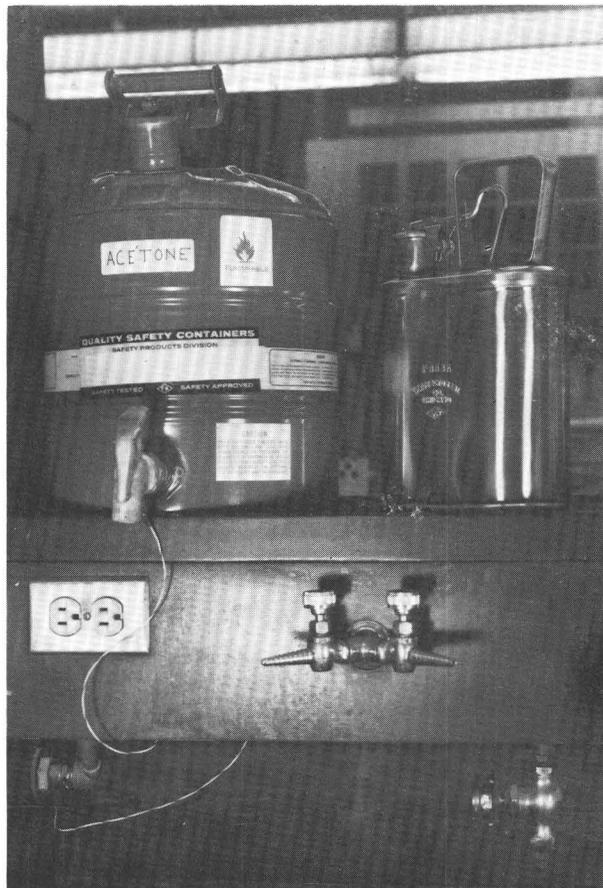


FIGURE 3. Approved, grounded, safety solvent-storage can; note alligator clip grounding can to plumbing. Also, note self-closing safety valve. Photograph by Louise Hedricks.



FIGURE 4. Some common types of labels used for identifying hazardous chemicals.

relative to the contents, hazards, and first aid procedures. Any bottle without a label should not be used until the contents have been identified. If a container has not been properly labeled and the

degree of hazard is not known, the contents generally should be assumed to be dangerous to life. Excessive caution is definitely commendable in this type of situation. Carelessness can be lethal.

FLAMMABLE SOLVENTS

The first set of chemicals to be discussed in detail are the flammable solvents: acetone, benzene, methanol, methyl ethyl ketone, toluene, and xylene.

The hazards from flammable solvents are those to health and from fire. Inhalation of the vapors can be fatal if prolonged at high concentrations. For some solvents, chronic exposure at just the tolerance limit value can result in illness.

The fire hazard from solvents is great due to their physical properties. For the most part, water is ineffectual in extinguishing solvent fires.

Some solvents are not water-soluble, and water cannot cool most solvents below their flash point. Special fire extinguishers are needed to control solvent fires. These extinguishers bear a "B" rating and include carbon dioxide for small fires and dry chemical for gallon-size or larger spill fires. For special problems, such as data-processing equipment and sophisticated electronic instrumentation, Halon or AFFF foam extinguishers may be used if their greater cost is warranted (N. V. Steere, oral commun., 1979).

Vapors from solvents have a density greater than air. They tend to sink and can travel long distances to ignition sources where the flammable vapors will flash back to a fuel source.

ACETONE

Synonyms:	Dimethyl ketone, ketone propane, propanone.
Chemistry:	CH ₃ COCH ₃
Physical properties:	
Description:	Clear, colorless liquid having a mintlike odor and a sweet taste.
Molecular weight:	58.08
Melting point:	-94.6°
Boiling point:	56.48°C
Density:	0.797
Flash point:	-17.8°C
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV of acetone is 1,000 ppm (parts per million) in air, or 2.4×10^3 milligrams per cubic meter of air. Acetone is a narcotic in concentrations greater than the threshold limit. The symptoms of overexposure are dizziness, headache, coughing, irritation of the respiratory tract, and, in more extreme cases, unconsciousness. The symptoms of slight exposure (dizziness, headache) are quickly relieved by removing the victim to fresh air. The effects will disappear in 1–2 hours.

In the case of overexposure by inhalation, remove the victim to fresh air and administer artificial respiration if necessary; *immediate medical help is imperative*. For external exposure: acetone will dissolve skin fat upon contact and cause dryness. Hand lotion will help avoid cracking and will relieve irritation. If acetone is splashed in the eye, irrigate with large amounts of water and call a physician.

HAZARDS AND EMERGENCY ACTION

Acetone is classified as a flammable liquid and is extremely dangerous when exposed to heat or flame. Even mixed with water, a solution of greater than 10 percent acetone is flammable, having a flash point of 27°C. The fact that acetone is ex-

tremely volatile adds to its hazard potential. Explosive vapors can soon saturate the air in the event of a spill. *Keep acetone away from any heat or possible ignition source*. In the event of a fire, a carbon dioxide (CO₂), or dry-chemical extinguisher will smother the blaze. Water will be effective only when there is less than 10 percent acetone remaining. Also remember that any heavy liquid diluted with greater than 10 percent acetone will also burn just like an acetone fire.

STORAGE AND HANDLING

Acetone will dissolve some types of plastic, and therefore care must be taken in its storage. Acetone is safely kept in containers of teflon, polypropylene, polymethylpentene, and glass. It cannot be stored or transferred in polycarbonates or polyvinyl chloride containers. Care must be taken with the plastic laboratory gloves and aprons used when handling acetone. Acetone also must be stored in a well-ventilated area. When transferring from a larger drum, use a self-closing faucet and be certain that the drum is grounded effectively, as static electricity could generate a spark that may lead to a fire or explosion. (Hauff and Airey, 1980).

BENZENE

Synonyms:	Benzol, phenyl hydride, coal tar naphtha.
Chemistry:	C ₆ H ₆
Physical properties:	
Description:	Clear, colorless liquid.
Molecular weight:	78.11
Melting point:	5.51°C
Boiling point:	80.093°C to 80.094°C
Density:	0.8794 at 20°C
Vapor pressure:	100 mm at 26.1°C
Flash point:	-11°C
Vapor density:	2.77 (air=1.0)
Reference:	Sax (1975).

TOXICITY AND EXPOSURE SYMPTOMS, FIRST AID TREATMENT

Benzene is a toxic chemical that can cause many serious ill-health effects, including leukemia. Substitute solvents should be used if possible. If benzene must be used, ventilation is necessary and Federal regulations for monitoring employee exposure, medical examinations, and special training must be complied with (N. V. Steere, oral commun., 1979). The TLV for benzene is less than 10 ppm (McElwee, 1978). Localized exposure is indicated by irritation and burning of the skin. Exposure to unusually high vapor concentration (3,000 ppm) has a narcotic effect causing excitation and confusion (McElwee, 1978). These effects may include fatigue, headache, and a loss of equilibrium (Zenz, 1975). Chronic exposure can lead to or stimulate cancer in the blood or blood-producing tissues because benzene is a carcinogen. Although excessive accidental exposure can be hazardous, the greatest danger is to the worker who is repeatedly exposed to small amounts.

Benzene is readily absorbed through the skin and eyes so that direct contact must be avoided. If contact occurs, follow emergency procedures for immediate washing of the affected parts of the body for 15 minutes (as recommended previously).

Shoes, belts, and other apparel wet with benzene must be thoroughly washed or decontaminated before being reused (N.V. Steere, oral commun., 1979).

First aid treatment for acute exposure is to remove the victim to a well-ventilated area and apply artificial respiration, if needed, or oxygen. Recovery usually is complete without any obvious side effects. Frequent medical tests and observa-

tion for poisoning are advised for any overexposure case.

HAZARDS AND EMERGENCY ACTION

Benzene is an extremely flammable liquid and vapors can form explosive mixtures with air (National Fire Protection Assoc. (NFPA), 1975). Heavy vapors may travel to an ignition source and flash back.

If an explosion or large fire occurs, the Fire Department should be called immediately. *Do not attempt to deal with a large-scale fire without intensive fire training.* If the fire is small, carbon dioxide or dry chemicals may be used to extinguish it.

If a spill occurs, all ignition sources must be removed and maximum ventilation provided before attempting to clean up the spill. If the spill is large (more than 1 pint) and occurs outside a hood, there will be toxic fumes and the laboratory should be evacuated and closed off. Call the fire department immediately, as they have self-contained breathing apparatus for respiratory protection while cleaning up the spill.

If the spill is less than 1 pint and occurs within a hood, it probably can be cleaned up with the flammable solvent cleanup kit. However, be sure to wear protective clothing, goggles, rubber gloves, and a respirator. If the spill occurs outside of a hood and proper breathing protection is not available, **DO NOT ATTEMPT TO CLEAN IT UP.** Call the fire department.

STORAGE AND HANDLING

Because benzene is a moderately explosive and flammable liquid, it should be stored in a cool,

well-ventilated area with a downdraft. It also should be separated from oxidizing materials (NFPA, 1975). Benzene stored in the laboratory can be kept in a metal safety can that has been bonded. All containers must be labeled as such:

CAUTION—Contains Benzene—Cancer hazard.

Any work using benzene must be done in a special enclosure such as a glove box or under a properly operating fume hood. If a fume hood cannot be used, the worker must wear an adequate respirator as protection from these highly toxic

fumes. Work must then be done in a restricted area.

Because the constituents of a flammable solvents spill kit are not always known, caution must be taken in the disposal of benzene-saturated absorbent. The absorbent should be kept at a temperature less than 52°C in a tightly sealed and properly labeled disposal container.

An additional safety procedure would be to rotate the workers handling benzene so that no one person receives a greater potential exposure to this extremely dangerous material.

METHANOL

Chemistry:	Methyl alcohol, carbinol, wood alcohol.
Physical properties:	
Description:	Clear, colorless, highly viscous liquid
Molecular weight:	32.04
Boiling point:	64.8°C
Melting point:	-97.8°C
Density:	0.7913 at 20°C
Vapor pressure:	10 mm at 21.2°C
Flash point:	11.1°C
Vapor density:	1.11
Reference:	Sax (1975).

TOXICITY, EXPOSURE SYSTEMS, AND FIRST AID TREATMENT

Methanol is eliminated from the body at an extremely slow rate. It should be considered a cumulative poison. As with other cumulative poisons, nonfatal acute exposure is not as dangerous as is daily TLV overexposures.

The TLV for methanol is 200 ppm (260 mg/m³) (McElwee, 1978). Symptoms that occur with an overexposure from concentrations of 500 ppm are headache, dizziness, and gastrointestinal disturbances. The main toxic effect is on the nervous system, and especially on the optic nerve. If blindness occurs, it may be permanent. Acute exposure at 2,000 ppm may result in coma and eventual death. Hospitalization is required with high overexposure cases (McElwee, 1978).

Suggested first aid treatment for eye and skin contact: flush the eyes with large volumes of water; use soap and water to remove methanol from the skin.

HAZARDS AND EMERGENCY ACTION

Methanol is flammable and has an explosive vapor. It can react vigorously with oxidizing mate-

rials. A small fire can be extinguished with carbon dioxide or dry chemicals.

Small spills may be cleaned up with a flammable solvent cleanup kit, but only after ignition sources have been removed from the area. Adequate ventilation must be provided during this cleanup operation. Personal protection also must be worn during the cleanup process, and the waste materials should be disposed of properly (Federal Register, 1980a,b).

STORAGE AND HANDLING

An important consideration in the storage of any flammable solvent is that good ventilation is needed in order to dilute to nonexplosive concentrations any vapors that may escape from the containers.

Methanol should be stored separately from all oxidizing materials.

While working with this flammable solvent, keep ignition sources away from the immediate area. Goggles or face shield, apron, rubber gloves, and respirator are necessary protective wear. Fume-hood ventilation also is necessary.

METHYL ETHYL KETONE

Synonyms:	Ethyl methyl ketone, MEK, 2-butanone.
Chemistry:	$\text{CH}_3\text{COC}_2\text{H}_5$
Physical properties:	
Description:	Colorless liquid with acetone-like odor.
Molecular weight:	72.1
Melting point:	-85.9°C
Boiling point:	79.57°C
Density:	0.80615 at 20°C
Vapor pressure:	71.2 mm at 20°C
Flash point:	-5.55°C
Vapor density:	2.41
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 200 ppm (590 mg/m³) (McElwee, 1978). Overexposure by inhalation is marked by a narcotic effect (Sax, 1975). Although no permanent disability is reported, the victim should be removed to fresh air if headache, nausea, or dizziness occurs (McElwee, 1978). MEK vapors are irritating.

Flush eyes with water for 15 minutes and wash skin with soap and water in the case of direct contact.

HAZARDS AND EMERGENCY ACTION

Methyl ethyl ketone is dangerous when exposed to heat or flame, and the fumes form an explosive mixture with air. Heavy vapors may travel to an ignition source and flash back on ignition. MEK, as well as other flammable liquids, should not be mixed with chromic acid.

Carbon dioxide or dry chemical extinguishers

may be used successfully on MEK in the event of a small fire.

Spills of less than 1 pint can be cleaned up with the standard flammable solvents kit. Extinguish any ignition source and ventilate the area before starting the cleanup. Protective gear and a chemical cartridge respirator also should be worn during cleanup procedures. The spill can be absorbed and the MEK evaporated, in a hood, from the absorbent material and then disposed of conventionally.

STORAGE AND HANDLING

As MEK is a flammable solvent, it must be stored in a cool, well-ventilated place, in a tightly sealed container. Waste material containing any spilled solvent should be stored in the same fashion until it can be disposed of properly.

This chemical should always be handled under a hood during transfer or use. Gloves are necessary protective gear when handling MEK. Wearing a cartridge respirator is suggested for any out-of-hood work.

TOLUENE

Synonyms:	Methylbenzene, phenylmethane, toluol.
Chemistry:	$C_6H_5CH_3$
Physical properties:	
Description:	Colorless, coal-tar distillate, benzol-like odor.
Molecular weight:	92.13
Melting point:	-95.0 to -95.5°C
Boiling point:	110.4°C
Density:	0.866 at 20°C
Vapor pressure:	36.7 mm at 30°C
Flash point:	4.44°C
Reference:	Sax (1975).

TOXICITY, EXPOSURE SYMPTOMS, AND FIRST AID TREATMENT

The TLV ranges from 13 ppm (50 mg/m³) to 200 ppm (750 mg/m³) (McElwee, 1978). Inhalation of toluene in excessive concentrations can lead to narcosis, headache, loss of coordination, coma, and death by paralysis (McElwee, 1978). With low level exposure, however, recovery without permanent damage usually occurs. Occasional cases of chronic poisoning can result in diseases of the blood and bone marrow (Sax, 1975).

Eyes contacted by toluene should be flushed for at least 15 minutes with water. Skin should be washed immediately with soap and water.

HAZARDS AND EMERGENCY ACTION

Toluene is explosive when exposed to heat or flame. It can react vigorously with oxidizing materials and emits toxic fumes when heated. Heavy vapors may travel considerable distances to an ignition source and flash back (NFPA, 1975).

Small fires can be put out with carbon dioxide or dry chemical extinguishers. Ignition sources must first be extinguished and maximum ventilation provided in case of a spill. If less than 1 pint

of solvent is involved, a spill cleanup kit can be used to absorb the spilled liquid. Any absorbent material saturated with toluene should be ventilated in a hood until the toluene is evaporated, or sealed into a labeled waste container and disposed of properly.

STORAGE AND HANDLING

Due to toluene's flammable properties, it must be stored in tight containers in a cool, well-ventilated area, away from oxidizing materials. A standard flammable-liquids storage cabinet or room is recommended.

All flammable solvents need adequate ventilation when being transferred from one container to another. Bonding of the transfer container also is suggested to prevent sparks from static electricity buildup.

Waste material from a spill cleanup should be stored in tightly sealed, labeled containers until disposed of properly.

Work with toluene should be done under a fume hood. The worker is advised to wear rubber gloves. When work is done outside a hood, wearing a cartridge respirator is recommended to avoid fume inhalation.

XYLENE

Synonyms:	M-xylol, ortho-xylene, meta-xylene, paraxylene.
Chemistry:	$C_6H_4(CH_3)_2$
Physical properties:	
Appearance:	Clear, colorless liquid.
Molecular weight:	106.2
Melting point:	47.9°C
Boiling point:	139°C
Density:	0.864 at 20°/4°C
Vapor pressure:	10 mm at 28.3°C
Flash point:	29°C
Vapor density:	3.66
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The acute toxicity of xylene appears to be greater than that of either benzene or toluene (Zenz, 1975). The vapors are a respiratory irritant that act as an anesthetic. The effects include drowsiness, fatigue, headache, and a loss of equilibrium (Zenz, 1975). Xylene can be absorbed through the skin. Skin contacted by xylene should be washed with soap and water.

HAZARDS AND EMERGENCY ACTION

Heavy vapors will form explosive mixtures with air, and can sink and travel to an ignition source.

Note that the flash point of xylene is near room temperature. Should a fire involving xylene occur, it can be extinguished using carbon dioxide or dry chemicals (NFPA, 1975).

STORAGE AND HANDLING

Storage should be in glass or metal containers, separate from oxidizing materials in a flammable liquid storage cabinet. The room should be cool and well-vented.

Handling of xylene should be done in a well-ventilated area while wearing protective gear.

CORROSIVE LIQUIDS

Geology laboratories use the more common acids and bases. These liquids will be discussed in this section.

The hazards involving caustic liquids are mainly those of inhalation or of direct body contact. The fire hazard is not nearly as great as that of flammable solvents. However, some corrosives react with other materials to produce explosive, gaseous mixtures.

If a fire should occur, water can be used to fight it. Sulfuric acid is the exception. Water should not be applied to a sulfuric acid fire as the acid reacts violently with water and splatters. However, water should be used for flushing skin if sulfuric acid splashes on the body.

Careful handling of the following chemicals is extremely important because of the immediate and possibly permanent damaging effects that they have on living tissue. The worker should not come in direct skin contact with acids or strong bases nor inhale their corrosive fumes.

In general, do not induce vomiting if any corrosive is ingested, as the upper digestive system will then be burned twice. Instead, first have the victim drink cold water (which dilutes the corrosive) followed by a protective coating substance such as egg whites or milk. Use of sodium bicarbonate, although a neutralizer, is to be avoided. It reacts with strong acids to release carbon dioxide, which causes gastric distension and sometimes rupture (Zenz, 1975).

ACETIC ACID, GLACIAL

Synonyms:	Methane carboxylic acid, vinegar acid, ethylic acid, ethanoic acid.
Chemistry:	CH ₃ COOH
Physical properties:	
Description:	Colorless liquid, pungent odor of vinegar.
Molecular weight:	60.05
Melting point:	16.7°C
Boiling point:	118.1°C
Density:	1.049 at 20°C/4°C
Vapor pressure:	11.4 mm at 20°C
Flash point:	42.77°C
Vapor pressure:	2.07
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 10 ppm (McElwee, 1978). Inhalation of vapors can produce irritation, swelling of the liver, and blackening of the teeth. Chronic respiratory effects can result from daily exposure. If ingested, cardiovascular collapse, vomiting, and pain in the mouth and stomach may result (McElwee, 1978).

In the case of contact with the eyes, skin, or clothing, remove contaminated clothing and flush contacted body areas with water for at least 15 minutes. Magnesia, chalk, or whiting in water should be given if acetic acid has been swallowed.

HAZARDS AND EMERGENCY ACTION

Acetic acid is a combustible liquid that gives off flammable concentrations of vapors if heated to more than 43°C (N. V. Steere, oral commun., 1979).

Upon exposure to flame, the explosion hazard is moderate. Acetic acid decomposes when heated and emits toxic fumes.

Acetic acid should not be mixed with chromic acid, nitric acid, sodium peroxide, hydrogen peroxide, or other oxidizing materials. It should

not be mixed with solvents unless the correct procedure for doing so is known.

Small fires may be extinguished with carbon dioxide, dry chemical, or water spray.

Spills can be cleaned up by first neutralizing the acid with sodium bicarbonate. This mixture is diluted with water, and the resulting slurry can be scooped up and flushed down a drain with excess water.

STORAGE AND HANDLING

Storage must be in glass bottles or carboy containers. The new, plastic-covered glass bottles also are recommended. The storage area should be well-vented and at a temperature higher than the freezing point of the acid. Even though the acid first contracts slightly upon freezing (Merck and Co., 1978–1979), it will eventually expand and break the containers (NFPA, 1975). Acetic acid should be kept separate from all oxidizing materials.

Work with acetic acid should be done in a well-ventilated hood while wearing goggles, protective clothing, and rubber gloves. Work outside a hood requires wearing a respirator.

AMMONIUM HYDROXIDE

Synonyms:	Aqua ammonium, water ammonium, aqua ammonia, ammonium hydrate.
Chemistry:	NH ₄ OH
Physical properties:	
Description:	Colorless liquid with pungent odor.
Molecular weight:	35.05
Melting point:	-77.0°C
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV for ammonium hydroxide is 25 ppm (McElwee, 1978). Exposure occurs by direct contact or by inhalation of the vapors that are given off at increasingly higher rates as the liquid is heated. This material is an irritant and its corrosive action can inflict burns to the skin, ulceration of the cornea, and, when inhaled, pulmonary edema and respiratory inhibition (Sax, 1975). If exposure by inhalation does not exceed 500 ppm for 1 minute, the exposure effects do not usually last more than a few days (McElwee, 1978).

In the case of direct contact, skin and eyes must be flushed with water for at least 15 minutes.

HAZARDS AND EMERGENCY ACTION

Toxic fumes are emitted when ammonium hydroxide is heated. Mixing NH₄OH with hydrochloric acid will produce an increase in temperature and pressure. This mixing should not be done in a closed container (NFPA, 1975). These chemicals do, however, appear to be incompatible when mixed in concentrated solutions. Ammonium hydroxide should *not* be mixed with sodium hypochlorite (T. Ging, oral commun., 1979) because phosgene gas with a TLV of 0.1 ppm is formed (OSHA, 1976).

Spills of less than 1 pint may be cleaned up using a caustic spill kit. The appropriate personal safety gear must be worn when handling or cleaning up after this chemical. If the spill occurs outside a hood, then wearing a respirator is mandatory.

STORAGE AND HANDLING

Ammonium hydroxide can be stored in either glass or plastic containers. It should be stored in a cool, well-ventilated room and kept from oxidizing materials (Sax, 1975). If NH₄OH is stored close to an oxidizing agent such as HCl, whiskers of ammonium chloride will form around the bottle tops. Ammonium chloride in itself is not unduly hazardous.

A fume hood is a requisite work area when handling ammonium hydroxide. The standard protective safety gear is also required (McElwee, 1978).

FORMIC ACID

Synonyms:	Methanoic acid, hydrogen carboxylic acid.
Chemistry:	HCOOH
Physical properties:	
Description:	Colorless, fuming liquid, pungent penetrating odor.
Molecular weight:	46.03
Boiling point:	100.8°C
Melting point:	8.2°C
Density:	1.2267
Vapor pressure:	40 mm at 24°C
Flash point:	68.88°C (90 percent solution 50°C).
Vapor density:	1.59
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 5 ppm (McElwee, 1978). When direct contact is made, formic acid can cause burns through its corrosive action on the skin. It has a great affinity for human tissue. It is the chemical that ants inject when biting.

Eyes should be flushed with water for at least 15 minutes. After flooding the skin with water, a sodium bicarbonate-water paste can be applied to further neutralize the acid (Gosselin and others, 1976).

HAZARDS AND EMERGENCY ACTION

The fire hazard of formic acid is moderate with exposure to heat or flame. This acid is water-soluble, and, if a fire should occur, it can be extinguished with water. Carbon dioxide or dry chemicals also can be used to put out formic acid fires.

"The combination of formic acid, hydrogen peroxide, and organic matter has resulted in a violent explosion" (Chemical and Engineering News, 1950). An explosion also has occurred when furfuryl alcohol was mixed with formic acid (Chemical and Engineering News, 1940). Caution should be taken when using sulfuric acid with formic acid,

as the sulfuric acid may dehydrate the formic acid to produce poisonous carbon monoxide gas.

Spills of less than 1 pint can be cleaned up using soda ash or sodium bicarbonate. Protective gear must be worn.

STORAGE AND HANDLING

Storage of formic acid should be in a cool, dry, well-ventilated place with temperature control so that the acid does not freeze, especially if glass is used for storage containers. Glass bottles or plastic-coated glass bottles, and some plastics can be used for storage. Formic acid must be kept separate from sulfuric acid and oxidizing materials (NFPA, 1975).

Properly neutralized waste material from a spill cleanup may be washed down a drain with excess water, provided that local regulations permit this.

Work with and transference of this acid must be done in a well-ventilated area or fume hood. Protective clothing, face shield or goggles, rubber gloves, and apron, must be worn. Self-contained breathing apparatus is suggested in the event of a spill that cannot be properly ventilated to dilute the fumes.

HYDROCHLORIC ACID

Synonyms:	Muriatic acid, chlorohydric acid, hydrogen chloride, hydrochloride.
Chemistry:	HCl
Physical properties:	
Description:	Colorless, fuming liquid, acrid odor.
Molecular weight:	36.47
Melting point:	-114.3°C
Boiling point:	84.8°C
Density:	1.639
Vapor pressure:	4 atm at 17.8°C
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 5 ppm (7 mg/m³) (McElwee, 1978). Exposure from inhalation of fumes, ingestion, or direct skin contact with the liquid can cause burns, perforation of the nasal septum, respiratory problems, burning and perforation in the digestive tract, chills, fever, anxiety, and shock. Prolonged exposure to low concentrations causes erosion of the teeth (Patty, 1963). At 500 ppm, death can occur in 30 minutes (T. Ging, oral commun., 1979).

Eyes should be flushed with water; skin washed with soap and water. Alkalies, such as those associated with soap, should be used carefully due to the possible formation of gases. If HCl is ingested, gastric lavage should be given using 5-percent sodium bicarbonate solution followed by instillation of aluminum hydroxide gel (McElwee, 1978). Alkalies, again, should be used carefully to prevent the formation of gas.

There is little known about the long-term disabling effects of hydrochloric acid on the body.

HAZARDS AND EMERGENCY ACTION

Hydrochloric acid and its fumes are nonflammable, but reaction with metals can generate hydrogen gas that is highly explosive if concentrated.

In general, HCl should not be mixed with solvents unless the correct procedure is known (M. Sawyer, written commun., 1978). HCl also will react with water or steam to produce toxic and corrosive fumes (Sax, 1975).

Hydrochloric acid spills of less than 1 pint can be cleaned up using the general acid-spill cleanup kit. As in all such emergencies, the appropriate protective gear must be worn. Waste material from an HCl spill contains alkali and alkaline earth salts that are, in themselves, toxic. This waste material should therefore be handled carefully and disposed of properly.

STORAGE AND HANDLING

Hydrochloric acid should be stored separately from oxidizing materials and all metals. Containers must be glass and must be kept in a well-ventilated, cool, dry place.

Work with and transference of hydrochloric acid must be done with adequate ventilation. The requisite safety clothing of safety glasses, goggles or face shield, rubber gloves, and apron or lab coat must be worn to avoid overexposure and injury. Wearing a respirator is necessary if use of a hood is not possible.

HYDROFLUORIC ACID

Synonyms:	Hydrogen fluoride, fluorohydric acid.
Chemistry:	HF
Physical properties:	
Description:	Colorless, fuming, corrosive liquid.
Molecular weight:	20.01
Melting point:	-92.3°C
Boiling point:	19.4°C
Density:	0.987
Vapor pressure:	400 mm at 2.5°C
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 3 ppm (2 mg/m³) (McElwee, 1978). Hydrofluoric acid is extremely dangerous as it can extensively damage the skin and cause blindness upon immediate contact with the eyes (NFPA, 1975). The effects of HF are insidious, with pain not always felt at the time of contact (J. T. Baker Chemicals, 1977). Subsequently, the victim should see a physician if there is even a suspicion of contact with HF.

Inhalation of hydrofluoric acid can result in respiratory ulcers, pulmonary edema, and shock. Ingestion may cause burns of the digestive tract and may be fatal if swallowed. Muscle spasms, convulsions, nausea, vomiting, and diarrhea can be indications of serious poisoning (McElwee, 1978). With extended exposure, HF is absorbed through the skin and can move into the joints, potentially causing a painful and debilitating type of arthritis.

Eyes must be irrigated with water for 15–30 minutes after an exposure to HF. Skin contact with an HF solution of greater than 20 percent should be treated by flushing the area with cold water. Alkaline soap should be used in order to increase the wettability of the surface (Gosselin and others, 1976). Soak affected area in iced magnesium sulfate solution (25 percent) while obtaining medical help. Further treatment requires infiltration of calcium gluconate (Gosselin and others, 1976), and may include a long-term diet high in calcium (McElwee, 1978). Treatment of skin burns by less than 20-percent HF solution should be done by flushing the area with cold water, then immersing in an iced solution of ethyl alcohol or benzalkonium chloride for 1–4 hours (Gosselin and others, 1976). If treatment is immediate, calcium injections may not be necessary

(Gosselin and others, 1976). It must be cautioned, however, that the ethyl alcohol commonly used in most laboratories may contain methanol and (or) benzene that would make this alcohol undesirable to use for such treatment (T. Ging, oral commun., 1979).

Despite immediate emergency treatment of HF burns, gangrene of the subcutaneous tissues can develop, causing permanent disability.

Physical examination of workers regularly exposed to HF is suggested to help determine if chronic diseases are developing due to overexposure.

Appendix B contains detailed first aid treatment for HF burns.

HAZARDS AND EMERGENCY ACTION

Hydrofluoric acid, when heated or mixed with water (steam), will emit toxic, corrosive fumes (Sax, 1975). It should never be mixed with bismuthic acid, fluorine, nitric acid, lactic acid, sodium, or any solvent, as all these chemicals are incompatible with HF (J. T. Baker Chemicals, 1977).

If a spill of greater than 1 pint should occur, fire department help is required to clean it up. Small spills can be removed using a cleanup kit designed specifically for hydrofluoric acid spills. **DO NOT USE ANY OTHER ACID-SPILL CLEANUP KIT FOR HYDROFLUORIC ACID.** The regular acid kits may contain silicates or other incompatible substances. If clothing has been contaminated during cleanup, the garments should be discarded. Waste materials containing calcium and magnesium fluorides and acetate that may have been created when cleaning up an HF spill should be disposed of most carefully.

Water can be used to extinguish an HF fire, as can carbon dioxide and dry chemical extinguishers.

STORAGE AND HANDLING

Hydrofluoric acid should be stored separately from combustible materials and catalytic metals. A cool, well-ventilated place is needed. HF can be stored only in plastic containers, as it will corrode almost any other type of material. However, polyvinyl chloride or polycarbonate plastic contain-

ers should not be used (T. Ging, oral commun., 1979). Hydrofluoric acid destroys glass at a rapid rate and should never, even briefly, be put into a glass receptacle of any type.

Any handling of HF should be done with ventilation, preferably a fume hood. Protective safety clothing with goggles or face shield, neoprene gloves, and apron or lab coat should be worn; a respirator is also suggested.

For more information concerning the minimization of the hazards of HF, see Appendix A.

NITRIC ACID

Synonyms:	Aqua fortis, azotic acid, engravers acid, hydrogen nitrate.
Chemistry:	HNO ₃
Physical properties:	
Description:	Transparent, colorless or yellowish, fuming corrosive liquid.
Molecular weight:	63.02
Boiling point:	86.0°C
Density:	1.502
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 2 ppm (5 mg/m³) (McElwee, 1978). Exposure can occur by inhalation, ingestion, and direct skin contact with the liquid. Severe corneal and skin burns can occur unless eyes and (or) skin are flushed with water for at least 15 minutes and the skin is washed with soap or 5-percent sodium bicarbonate solution. Burns may be treated with a dressing of saturated solution of sodium thiosulfate (McElwee, 1978).

Inhalation of fumes can cause bronchopneumonia and pulmonary edema. The victim must be removed to fresh air, given artificial respiration, and oxygen, if necessary (McElwee, 1978). The vapors are extremely toxic!

Ingestion of nitric acid may result in perforation of the intestinal tract, asphyxiation due to glottic edema, and circulatory collapse.

If the acid is ingested, a soap solution, calcium or aluminum hydroxide, or magnesium oxide can be taken orally. Avoid the use of strong alkalis that will produce carbon dioxide that may increase the risk of intestinal perforation.

Symptoms of poisoning are sneezing, coughing, chest pain, dental erosion, nausea, and vomiting of blood. Hospitalization for observation is advised in cases of overexposure.

HAZARDS AND EMERGENCY ACTION

The fire hazard from nitric acid is moderate and is caused by chemical reaction with reducing agents (Sax, 1975).

Nitric acid reacts explosively with metallic powders, carbides, hydrogen sulfide, and turpentine,

and with acetic, chromic, and hydrocyanic acids, aniline and other easily nitrated substances (NFPA, 1975).

Fire involving nitric acid can be fought with water, as the acid is water soluble. Carbon dioxide and dry chemical extinguishers also may be used.

A nitric acid spill may be removed using a general acid-spill cleanup kit provided that the proper safety equipment is worn and that the spill is less than 1 pint.

As stated, HNO₃ is highly reactive with metals. Any spill involving metals and (or) sulfides must be handled carefully because poisonous gases can be created as reaction products. Wearing a respirator is advised when dealing with this type of problem.

STORAGE AND HANDLING

Nitric acid should be stored in glass containers in a well-ventilated area. It must be separated from metallic powders, carbides, hydrogen sulfide, turpentine, organic acids, organic and other combustible materials (NFPA, 1975). Nitric acid should be kept from direct sunlight. Waste material from a neutralized spill of HNO₃ can be washed down the drain if regulations permit this procedure.

If nitric acid is being transferred or is spilled outside a hood, wearing a self-contained breathing apparatus, or at least a respirator, is recommended to prevent the worker from overexposure to toxic fumes. Safety equipment such as goggles or face shield, neoprene gloves, and apron or lab coat also must be worn when working with nitric acid.

SODIUM HYDROXIDE

Synonyms:	Caustic soda, sodium hydrate, lye, white caustic.
Chemistry:	NaOH
Physical properties:	
Description:	White, deliquescent pieces, lumps, or sticks, may have faint sulfurous odor.
Molecular weight:	40.01
Melting point:	318.4°C
Boiling point:	1390°C
Density:	2.12 at 20°C/4°C
Vapor pressure:	1 mm at 739°C
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 3 ppm (2 mg/m³) (McElwee, 1978). Exposure can occur from inhalation or by absorption through the skin. Corrosive alkalies are more of a hazard than acids because they do not form as acids do a protein barrier that buffers skin tissue destruction. Ingestion can cause perforation or scarring. When mists, vapors, and dust of this compound are inhaled, reflexive respiratory inhibition and cardiovascular collapse, pneumonitis, coma, edema of the larynx, and asphyxiation can occur (McElwee, 1978).

After contact with sodium hydroxide, the eyes should be flushed for 15 minutes with warm water. If sodium hydroxide is spilled on clothes or skin, immersion in an emergency shower while removing clothing is necessary. If ingested, gastric lavage should be administered with 5-percent acetic acid followed by olive oil and demulcents.

Sodium hydroxide is not combustible, but may react with water or steam to produce enough heat to ignite combustible materials. Contact with some metals can generate hydrogen gas, which is itself explosive (NFPA, 1975).

If dilute sodium hydroxide should spill in small volumes, a caustic-spill cleanup kit can be used

to clean it up; larger volumes require professional assistance to neutralize. Adequate ventilation must be provided; a canister respirator and the standard protective safety gear should be worn. Neutralization of concentrated caustic materials produces heat, and a period of 2 minutes between treatment steps must be allowed for heat dissipation (J. T. Baker Chemicals, 1977).

STORAGE AND HANDLING

As with all corrosive chemicals, sodium hydroxide must be stored in containers not corroded by the chemical itself. Storage should be in a cool, well-ventilated, dry place protected against moisture and water. Waste material from a used spill cleanup kit contains citrate salts that need to be disposed of properly (J. T. Baker Chemicals, 1977).

This chemical must be separated from acids, metals, explosives, organic peroxides, and easily ignitable materials (NFPA, 1975).

Work with sodium hydroxide must be done under a hood. The standard protective gear including goggles, rubber gloves, apron or lab coat, and respirator, if necessary, must be worn when working with NaOH.

SULFURIC ACID

Synonyms:	Dipping acid, oil of vitriol, spirit of sulfur.
Chemistry:	H ₂ SO ₄
Physical properties:	
Description:	Colorless, oily liquid.
Molecular weight:	98.08
Melting point:	10.49°C
Boiling point:	330°C
Density:	1.834
Vapor pressure:	1 mm at 145.8°C
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is less than 1 ppm (1 mg/m³) (McElwee, 1978). Exposure to sulfuric acid can cause severe skin burns, corneal necrosis, staining of the teeth, and erosion of tissue in the mouth, throat, and abdomen (McElwee, 1978). Serious lung damage can result from prolonged inhalation and may be fatal from laryngeal spasm within 30 minutes. Corneal damage may be permanent (McElwee, 1978).

If overexposure should occur, the victim must be removed from the contaminated area and oxygen given if necessary. When contacted by H₂SO₄, eyes must be flushed with large volumes of water and skin washed with soap and water. If sulfuric acid is ingested, gastric lavage is necessary.

HAZARDS AND EMERGENCY ACTION

The fire hazard is moderate and is caused by chemical reaction. Sulfuric acid is a powerful oxidizer and can ignite upon contact with combustibles (Sax, 1975). Because of its violent reaction

with concentrated sulfuric acid, water should not be used to extinguish fires involving the acid. Dry chemical extinguishers are effective for putting out small fires.

Sulfuric acid is dangerous when heated because it emits highly toxic fumes.

A sulfuric acid spill may be cleaned up using a general acid-spill cleanup kit provided that the spill is less than 1 pint. The standard protective gear should be worn. Waste material from a spill cleanup should be disposed of carefully.

STORAGE AND HANDLING

Storage of this chemical must be in glass containers in a cool, well-ventilated room. It should be separated from water, carbides, chlorates, fulminates, nitrates, picrates, powdered metals, and combustible materials (NFPA, 1975).

All handling and transferring of sulfuric acid should take place where adequate ventilation can be provided. Goggles, chemical cartridge respirator, rubber gloves, and apron or lab coat should be worn when working with H₂SO₄.

HEAVY LIQUIDS

BROMOFORM

Synonyms:	Tribromomethane.
Chemistry:	CHBr_3
Physical properties:	
Description:	Colorless liquid or hexagonal crystals; odor similar to chloroform (when chloroform is used as preservative).
Molecular weight:	252.77
Melting point:	6°–7°C
Boiling point:	149.5°C
Density:	2.89 at 20°C
	Density varies due to preservative added. Pure bromoform is unstable and in pure form would decompose in several weeks. Preservatives are added to inhibit this decomposition. Ethynol and chloroform are commonly used. They are added in quantities of 1–2 percent which lowers the density to 2.85–2.88 (J. Swimmer, oral commun., 1978). Propylene oxide also may be used (R. Doll, oral commun., 1978). It requires only 0.5 percent by volume, giving a somewhat higher specific gravity than does bromoform stabilized with ethynol.
Flash point:	None (nonflammable).
Vapor pressure:	15 mm at 41° (Weast, 1970).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The threshold limit value (TLV) of bromoform is 0.5 ppm, which is 5 milligrams per cubic meter of air. Bromoform is listed as a suspected carcinogen (cancer agent) by NIOSH (1976). A major consideration is the fact that once bromoform is smelled in the air, the threshold limit for a person for an 8-hour day has been reached. An additional problem relative to determining the "safe" limits of exposure is the fact that each person can react differently to the same volume of fumes. We suggest that those workers whose prior working history shows them to be overly sensitive to the fumes should not be allowed to work in the parts of the laboratory where exposure is assured.

Bromoform is a contact poison and can be introduced into the body by external exposure. The symptoms of overexposure are: tearing, excessive saliva flow, reddening of the face, drowsiness or a state of apparent inebriation, or, with prolonged exposure, deep narcosis and death. Bromoform can cause extreme systemic damage. Repeated exposure can cause excessive damage to the liver, kidneys, heart, and lungs. Bromoform is potentially cumulative in the body, and therefore repeated overdose is highly dangerous.

Countermeasures for overexposure victims are:

remove the victim to fresh air, administering artificial respiration as needed; get medical assistance immediately. As halogenated hydrocarbons are known to potentiate adrenalin, adrenalin should not be administered to a victim of overexposure. In cases of severe acute poisoning, cardiac arrhythmia may occur, even from endogenous adrenalin (Patty, 1963). For skin contact, flush thoroughly with water and wash with soap. Remove contaminated clothing and wash it before reuse. Skin contact may be followed by burns that appear as second-degree inflammations.

HAZARDS AND EMERGENCY ACTION

When bromoform is combined with acetone, a common dilutant, the mixture becomes highly flammable. Fires from this solution are extremely hazardous because as the bromoform burns, and therefore decomposes, toxic fumes are liberated. Bromoform can explode on contact with lithium (NFPA, 1975). A mixture of bromoform and sodium-potassium alloy is especially sensitive to impact and can explode on standing at room temperature (NFPA, 1975). Bromoform also is incompatible with aluminum and magnesium.

If overheated to the point of decomposition (indicated by a color change) carbonyl bromide

(COBr₂) is produced that is highly toxic. A second byproduct of decomposition, hydrobromic acid (HBr) is a pale-yellow liquid that is highly corrosive and that releases toxic vapors that attack metal. Both compounds pose a hazard if inhaled.

A small bromoform spill can be cleaned up by squirting the spill with acetone and wiping it up with absorbent paper. The papers are disposed of as mentioned in the section on handling. In the event of a large spill, fuller's earth or kaolin powder can be sprinkled over the spill and allowed to absorb the heavy liquid.

STORAGE AND HANDLING

Bromoform is a halogenated hydrocarbon and will break down and darken due to free halogens emitted by exposure to heat and light. It should, therefore, be stored in amber glass bottles in a cool, dry place, preferably in an area of good ventilation.

Waste material from a spill cleanup should be stored in tightly sealed and labeled containers

until disposed of properly. Filter paper and absorbent towels or tissues contaminated with bromoform should be removed from the laboratory and should not be left in open waste containers outside the hood. A wire mesh basket, suspended or set in the hood, can be used during the day, while the hood is operating, to evaporate heavy liquid and solvent from saturated filter paper and tissues.

Any time that heavy liquids are handled, it is imperative to wear gloves, a rubber apron, and goggles or safety glasses. The gloves should be checked for cuts and tears. With prolonged exposure to a heavy liquid, most plastics will deteriorate. Work with bromoform should be performed under a fume hood that meets specifications of 160 feet per minute (fpm) face velocity. The additional precaution of wearing a filtered respirator also is advised. In the transfer of bromoform, care should be taken with any plastics exposed to the liquid. Glass and teflon should be used whenever possible (Hauff and Airey, 1980).

METHYLENE IODIDE

Synonyms:	Diiodomethane.
Chemistry:	CH ₂ I ₂
Physical properties:	
Description:	Straw colored, clear liquid.
Molecular weight:	267.9
Melting point:	5-6°C
Boiling point:	181°C
Density:	3.325 at 20°C
Vapor pressure:	9.25 (air = 1.00)
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

There is minimal documented data on methylene iodide (MEI). Mr. Jerry Swimmer of the Geoliquids Division provided in-house literature (National Biochemical Co., 1975) listing physical properties and arbitrary precautions used in his manufacturing processes. The TLV is designated at 25 ppm per 8-hour working day. This value is suspect, and is significantly higher than the 0.5 ppm TLV for bromoform determined by ACGIH (American Conference of Governmental Industrial Hygienists). Until further tests are conducted on MEI and a specific standardized TLV is established, precaution is advised.

As MEI is considered a narcotic, overexposure can result in respiratory complication, vertigo, diplopia, and ataxia. Excessive overexposure may bring about unconsciousness. Skin contact with methylene iodide produces burns. The chemical appears to be absorbed through the skin and is deposited as inorganic iodine in the tissues (Patty, 1963). If overexposure should occur, the victim should be removed from the source to fresh air. Because little is known concerning the effects of MEI on the body, cases of overexposure should be referred to a physician as soon as possible. Eyes contacted by MEI need to be flushed with water and skin washed with soap and water.

HAZARDS AND EMERGENCY ACTION

MEI itself is not flammable, but the decomposed vapor will burn if exposed to open flames, releas-

ing large amounts of free iodine. It will decompose upon exposure to light and heat and will emit toxic iodine fumes. MEI often is diluted with acetone to lower the density. Keep in mind that although MEI is not itself flammable it becomes so when mixed with acetone.

STORAGE AND HANDLING

A main consideration in the storage of methylene iodide is that it is highly sensitive to light and decomposes quickly upon exposure. It should be stored in a dark, cool place, tightly sealed in amber glass bottles. Good ventilation also is recommended. A small piece of copper or silver wire mesh in the bottle theoretically will maintain the stability of the liquid, and thus the lighter color, for extended periods of time.

Transfer of MEI should take place only in adequate ventilation and using nonreactant tubing. In the various references available, no data were found on the resistance of various plastics to MEI. We suggest that any plastic to be used in prolonged contact with methylene iodide be tested before use. The assumption can be made for safety reasons that MEI reacts in a fashion similar to bromoform.

Waste material from a spill should be stored properly in a labeled, tightly sealed container. When using MEI, the precautions for working with a toxic liquid should be followed—adequate ventilation and protective laboratory clothing (Hauff and Airey, 1980).

OTHER CHEMICALS

HYDROGEN PEROXIDE

Synonyms:	Hydrogen dioxide, T-stuff.
Chemistry:	H ₂ O ₂
Physical properties:	
Description:	Colorless, heavy liquid or at low temperatures a crystalline solid.
Molecular weight:	34.016
Boiling point:	158°C
Density:	1.46 at 0°C
Vapor pressure:	1 mm at 15.3°C
Flash point:	None.
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

The TLV is 1 ppm (1.4 mg/m³) (McElwee, 1978). Exposure symptoms are skin and corneal burn, eczema, and lung irritation (McElwee, 1978). Although no permanent, damaging effects have been reported from overexposure to hydrogen peroxide, either by direct contact or by inhalation, treatment should be immediate, as the effects, if any, may be delayed (J. T. Baker Chemicals, 1979). Eyes must be irrigated with water and skin washed with soap and water. If the irritation and burning do not subside after careful flushing with water, a physician's assistance is required.

HAZARDS AND EMERGENCY ACTION

Because hydrogen peroxide is a powerful oxidizer, it increases the fire hazard of flammable materials with which it reacts. The explosion hazard of hydrogen peroxide itself increases as a function of concentration. It becomes more dangerous when exposed to heat, detonation caps, mechanical impact, or contamination with other substances. If a fire does occur, water can be used to dilute the chemical to a less-flammable concentration. Hydrogen peroxide normally is used in lower concentrations such as 30 percent and 3 percent in the average laboratory. At these lower values, the

hazards are still present but are less virulent. Violent decomposition can be caused by contact with iron, copper, chromium, brass, bronze, lead, silver, manganese, and their salts (NFPA, 1975).

Hydrogen peroxide spills may be cleaned up by diluting and washing down the drain with excess of water (MC/B Manufacturing Chemists, 1973).

STORAGE AND HANDLING

Hydrogen peroxide must be stored carefully due to its volatile nature. Containers must be kept capped to reduce fire hazard, but the container should *NOT* be sealed, as decomposition products can build up dangerously high pressure within the container.

Hydrogen peroxide should be stored in a cool place, away from direct sunlight. Combustibles, organic materials, readily oxidizable materials, and catalytic metals should not be stored near hydrogen peroxide (NFPA, 1975).

The standard safety equipment such as goggles or face shield, lab coat or apron, and vinyl or rubber gloves should be worn when working with hydrogen peroxide. Care must be taken with the gloves, as even a small tear or cut in the material can allow H₂O₂ to seep through and cause painful skin burns (NFPA, 1975).

SODIUM HYPOCHLORITE

Synonyms:	Clorox, eau de javelle, dazzle.
Chemistry:	NaClO
Physical properties:	
Description:	Clear, colorless liquid, strong odor.
Molecular weight:	74.45
Reference:	Sax (1975).

TOXICITY, EXPOSURE EFFECTS, AND FIRST AID TREATMENT

Inhalation of sodium hypochlorite may result in severe bronchial irritation and pulmonary edema, corrosion of the mucous membranes, and perhaps perforation of the esophagus or stomach. The latter may occur upon ingestion (Merck Index, 1978-79). Gastric lavage should be applied immediately. Sodium hypochlorite is a strong irritant. Skin and eyes must be flushed with water for at least 15 minutes upon contact.

The long-term effects or permanent damage from exposure to any type of sodium hypochlorite is unknown (Sax, 1975).

HAZARDS AND EMERGENCY ACTION

The fire hazard of sodium hypochlorite is moderate and is caused by chemical reaction with reducing agents. NaClO, when heated, can emit toxic, corrosive fumes, especially if used in high concentration. Sodium hypochlorite should not be mixed with ammonium hydroxide.

Water should not be used to put out a fire involving sodium hypochlorite (Sax, 1975). Carbon dioxide or dry chemical extinguishers are recommended.

Spills may be diluted with water and washed down the drain if regulations permit this disposal method.

STORAGE AND HANDLING

Sodium hypochlorite may be stored in glass or plastic containers. The storage facility should be dry, cool, and well ventilated. NaClO must be kept separate from reducing agents.

When working with high concentrations of sodium hypochlorite, goggles, apron or lab coat, and gloves should be worn. A fume hood must be used. When using this chemical as a dilute cleaning solution, safety wear may not be absolutely necessary, but care should be taken to avoid splashing the chemical into the eyes and on the skin. Good room ventilation always should be provided.

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APPENDIX A

HAZARDOUS MATERIALS HANDLING CHART

HAZARDOUS MATERIALS HANDLING

Chemical Name	<i>Flammable materials</i>	<i>Oxidizing materials</i>	<i>Toxic gas or vapor</i>	<i>Gas-vapor is irritant</i>	<i>Gas-vapor is narcotic</i>	<i>Skin burn or irritation</i>	<i>Toxic materials</i>	<i>Corrosive materials</i>	<i>Explosive when heated</i>
ACETONE	●			●	●	●	●		
BENZENE	●		●	●	●	●	●		●
METHANOL	●		●			●	●		●
MEK	●			●		●			●
TOLUENE	●				●	●	●		●
XYLENE	●		●	●	●	●	●		●
ACETIC ACID, GLACIAL			●	●		●	●		●
AMMONIUM HYDROXIDE			●	●		●	●		
FORMIC ACID			●	●		●	●		●
HYDROCHLORIC ACID			●	●		●	●	●	
HYDROFLUORIC ACID			●	●		●	●	●	●
HYDROGEN PEROXIDE		●		●		●		●	●
NITRIC ACID		●	●	●		●	●	●	●
SODIUM HYDROXIDE		●	●	●		●	●	●	
SODIUM HYPOCHLORITE		●		●		●	●		●
SULFURIC ACID		●	●	●		●	●	●	●
BROMOFORM			●	●	●	●	●	●	
METHYLENE IODIDE			●	●	●		●	●	

APPENDIX B

FIRST AID TREATMENT FOR HYDROFLUORIC ACID BURNS

FIRST AID TREATMENT FOR HYDROFLUORIC ACID BURNS

The following information is from Rhoda Rodger (written commun., 1979):

The manifestation of pain and (or) burns may be delayed from 1 to 24 hours when contact has been with a 1–20 percent solution of hydrofluoric acid. Hydrofluoric acid causes tissue destruction (necrosis) and the exposed area will be white in appearance. Hydrofluoric acid has an affinity for bone and will penetrate intact skin causing tissue damage all the way. Penetration of HF to the bone should be avoided. Sloughing of dead tissue from bone is made extremely difficult and healing extremely slow because (1) bone is surrounded by soft tissue, (2) bone has a poor blood supply, and (3) bone heals slowly. Blisters may result from HF contact if the burn is more severe because of higher concentrations of HF or from lack of timely treatment. Immediate medical treatment is essential.

TREATMENT

Time is of the essence! Treatment should be instituted immediately, within seconds if possible.

1. Flush with copious amounts of water.
2. Soak in a cold, super-saturated solution of magnesium sulfate (epsom salts) with ice cubes added for no less than 30 minutes. This solution should be made ahead of time and kept on hand in the refrigerator. To make solution: Boil distilled water (1,000 cm³ or more). Add magnesium sulfate until no more will dissolve. Allow to cool. Place in refrigerator in closed containers. Replace at least once a year.

Soak for 1–6 hours if HF concentration contacting skin is greater than 20 percent, or if there has been a delay in treatment for contact with 1–20 percent solutions. To prevent pain from the cold, remove the injured area from the solution every 10–15 minutes, allowing 1–3 minutes to warm, then resubmerge.

If the splashed area cannot be submerged, use heavy terry cloth towels for applying wet compresses of solution. Loosely wring the towel out of the cold magnesium sulfate solution to which ice cubes have been added. Cover the area thoroughly. Change towels frequently—every 2–3 minutes. Do not remove the first towel until the second towel is ready to apply. At least two people are needed to keep the

treatment continuous. Relief from the cold for the applicators' hands will be necessary.

3. Dress the area with generous amounts of magnesium oxide ointment and apply a pressure dressing. To change the dressing: clean off any ointment left on the area with alcohol-soaked cotton, then apply fresh ointment and a pressure dressing.

HOW OFTEN TO CHANGE THE OINTMENT:

- Every 15 minutes times 4
- Every 30 minutes times 4
- Every hour for rest of 24
- Twice a day for 5 days
- Once a day until healed

With severe burns (high concentrations) or delayed treatment if pain returns or sloughing of the tissue occurs, repeat the iced magnesium sulfate soaks and clean the wound of dead tissue at least once a day. More frequent applications (at least 4 times a day) of the ointment would be indicated.

EXTENSIVE CONTAMINATION:

1. Flush with copious amounts of water.
2. Submerge or compress with iced super-saturated magnesium sulfate solution.
3. Transport to doctor or hospital emergency room familiar with treatment of HF.
4. Continue submersion or compresses during transport.

The following is taken from Gosselin and others (1976).

Treatment of HF burns of skin where HF concentration was 20 percent or more (Iverson and Laub, 1970; Reinhardt and others, 1969; Scharnweber, 1969):

1. Wash all exposed areas copiously with cold tap water. Alkaline soap also may be helpful, especially in promoting the wettability of surfaces; a weak borax solution also can achieve the same result.
2. Irrigate exposed eyes with large volumes of water or weak boric acid solution followed by water.
3. Infiltrate exposed area with 10-percent calcium gluconate. Use a 30-gauge needle and small volumes that do not distend tissues (0.5 mL/cm²). Relief of pain by infiltration is a useful index to the adequacy of treatment. If the patient cannot tolerate the pain, local anesthesia may be given prior to calcium gluconate.

4. If further treatment is to be delayed, soak areas in iced magnesium sulfate solution (25 percent).
 5. Anesthetize area, excise burn eschar, and debride it. Do not hesitate to remove fingernails or toenails, because HF apparently passes through these structures without visible damage.
 6. Anticipate pulmonary edema.
- Treatment of HF burns of the skin where HF concentration was less than 20 percent (Dibbell and others, 1970; Reinhardt and others, 1969):
1. Spray water over affected area. Remove contaminated clothing and accessories.
 2. Immerse affected skin area in an ice-cold aqueous or alcoholic (95-percent ethyl alcohol) solution of Hyamine 1622 or some similar high-molecular-weight quaternary ammonium salt such as benzalkonium chloride (Zephiran). Use wet gauze compresses in which ice cubes are wrapped, if the lesion cannot be immersed. Keep this solution away from the eyes. Interrupt the soaking occasionally to avoid cold injury. If this soaking is continued for 1–4 hours, local infiltration with calcium gluconate is thought to be unnecessary and undesirable.
 3. If blisters form, institute debridement as described above.
 4. After soaking, apply a magnesium oxide-petrolatum ointment or a steroid ointment.

