Chapter 7
Chemical Hazards

OVERVIEW

Chemical hazards come in a variety of forms. Some chemicals are toxic or corrosive in nature; others are unstable when exposed to certain compounds or conditions; still others are carcinogenic or mutagenic. Most of the chemicals used in schools do not pose serious dangers. However, there are some chemicals that require more careful handling and others that should be avoided altogether. It is also important to know proper clean-up procedures, in case a spill does occur.

Before working with any chemical, particularly regulated or hazardous substances, teachers and students should be thoroughly familiar with its chemical and physical properties. Where possible, control risks by limiting chemical concentration and exposure. Keep in mind that "*The dose makes the poison*"; in other words, the higher the concentration of a chemical, the higher the toxic or corrosive hazard.

GENERAL SAFETY MEASURES

The following general guidelines can be followed to increase the margin of safety when working with chemicals.

- Ensure that the chemical is appropriately labelled and that the MSDS is readily available.
- Minimize exposure.
- Ensure that the acquisition, use and storage of toxic materials are based on real needs: if safer alternatives exist, use them.
- Do not handle or use hazardous chemicals unless you are WHMIS trained.
- Do not engage other staff in handling and using hazardous chemicals if they are not WHMIS trained.
- Before using any chemical, review its MSDS to determine potential hazards.
- Inform students of hazards and the necessary safety precautions. Never underestimate risks when mixing chemicals.
- Be prepared for accidents.
- Ensure chemicals and chemical wastes are stored with proper hazard identification.
- Do not keep stock bottles in the laboratory.
- Store chemicals in minimum quantities and in lower concentrations.
- Do not use toxic materials unless there is adequate protection from exposure.

CODE OF PRACTICE

Schools that stock any of the following substances should note that there is a specific Occupational Health and Safety Code requirement that may apply, depending on the quantity of material stocked.

arsenic and compounds	ethylene dibromide	methyl bromide
asbestos	ethylene oxide	methyl hydrazine
benzene	hexachlorobutadiene	perchlorates
beryllium	hydrazines	silica, crystalline
1,3-butadiene	hydrogen sulphide	styrene
cadmium	isocyanates	vinyl chloride
coal tar pitch volatiles	lead and compounds	zinc chromate

If the amount stocked for any of these substances exceeds the following quantities, the employer [in this case the school board] must have a code of practice governing the storage, handling, use and disposal of the substance. The amount on any of these substances that would trigger this requirement is specified as:

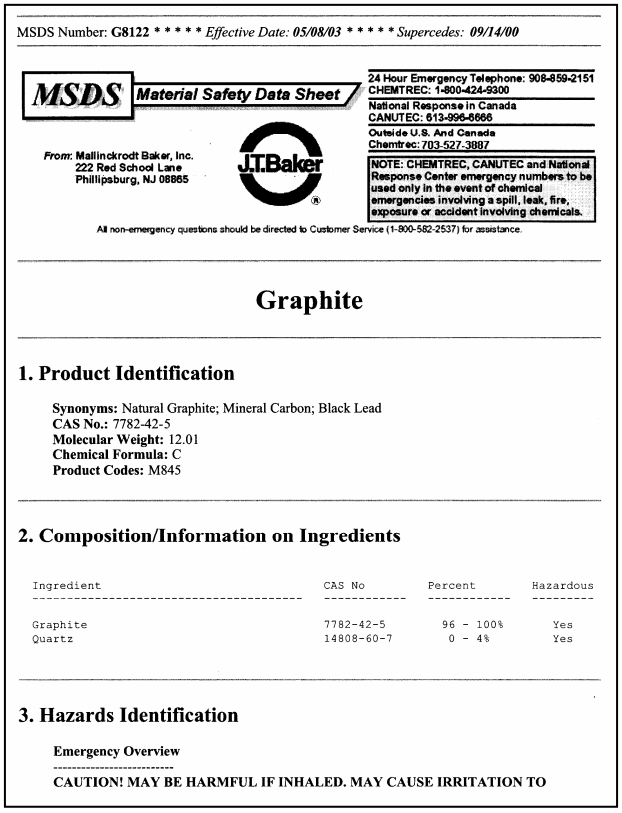
- 10 kilograms if in the form of a pure substance
- 10 kilograms if it is a component of a mixture in which it forms at least 0.1% of the mixture.

The code of practice must include measures to be used to prevent any uncontrolled release of the substance and the procedures to be followed if there is an uncontrolled release.

For further information on this requirement, see the *Occupational Health and Safety Code* Part 4, Section 26(1) at http://www3.gov.ab.ca/hre/whs/publications/pdf/ohsc-1.pdf and the corresponding section of the *Occupational Health and Safety Code Guide* at http://www3.gov.ab.ca/hre/whs/law/ohs_regcode_down.asp#eg.

MATERIAL SAFETY DATA SHEETS

Material safety data sheets (MSDSs) give detailed information about a chemical's composition, reactivity and health effects, as well as which protective equipment, safety procedures and emergency procedures to use. These sheets must be prepared by the product supplier and provided to the user (in this case the school) for all controlled chemicals. Suppliers may also be asked for MSDSs for other chemicals they supply. The MSDSs supplied by a chemical supply company are the legal source of information for those chemicals in case of an accident. In addition to the MSDSs supplied by chemical supply companies on order of chemicals, a variety of sources are available through MSDS online at http://www.ilpi.com/msds/index.html. Unfortunately, some sites listed have limited access, particularly for print-outs. A Web site with an extensive listing of chemicals and a number of companies from whom MSDSs can be obtained is available at http://www.msdssolutions.com.



MSDS Number: **G8122** * * * * * *Effective Date:* ***05/08/03*** * * * * * *Supercedes:* ***09/14/00***

MSDS Material Safety Data Sheet

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

J.T.Baker

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300
National Response in Canada
CANUTEC: 613-996-6666
Outside U.S. And Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

Graphite

1. Product Identification

Synonyms: Natural Graphite; Mineral Carbon; Black Lead
CAS No.: 7782-42-5
Molecular Weight: 12.01
Chemical Formula: C
Product Codes: M845

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Graphite	7782-42-5	96 - 100%	Yes
Quartz	14808-60-7	0 - 4%	Yes

3. Hazards Identification

Emergency Overview

CAUTION! MAY BE HARMFUL IF INHALED. MAY CAUSE IRRITATION TO

MSDSs are an essential source of information about chemical hazards, so it is important that teachers and students be able to understand the sheets from a variety of suppliers. Although the numbering of sections and the order of appearance may differ from supplier to supplier, the following information must be on each MSDS:

I. PRODUCT IDENTIFICATION AND USE
- Manufacturer's Name
- Supplier's Name

II. HAZARDOUS INGREDIENTS

III. PHYSICAL DATA
- Colour, form, solubility
- Melting and boiling points
- Vapour pressure, specific gravity

IV. FIRE AND EXPLOSION DATA
- Flammability
- Flashpoint
- Fire-fighting procedures

V. REACTIVITY DATA
- Stability and Hazards

VI. TOXOLOGICAL PROPERTIES
Threshold Limit Values (TLV)
Effects of exposure
Carcinogenicity

VII. PREVENTATIVE MEASURES
Protective clothing
Protective equipment
Spill and handling procedures

VIII. FIRST AID MEASURES

IX. PREPARATION DATE OF MSDS

MSDSs are dated and expire at the end of a three-year period. Updating of MSDSs is generally done at the same time that the chemical inventory is updated. Official MSDSs can be filed in hard copy form or on a computer, as long as they are readily available to all staff using these chemicals. Online access to specific company MSDSs may also be available, but this method requires tracking the chemicals and the companies from which each chemical was ordered if more than one supply company was used. For more information about chemical management, see Chapter 8.

TOXIC AND CORROSIVE CHEMICALS

Toxic or corrosive properties are the most common hazards posed by chemicals in schools (see the Chemical Hazard Information Table in Chapter 9 for information about specific chemicals). A toxic substance is any substance that may cause damage by its chemical action when ingested, inhaled, absorbed or injected into the body in relatively small amounts. Damage can occur when materials:

- directly destroy tissue through corrosive action; e.g., NaOH reacts with moisture in the skin
- interfere with chemical reactions of the body; e.g., CO replaces O2 in hemoglobin
- disrupt the biological processes of the body; e.g., NO2 causes pulmonary edema and allergic responses.

Exposure to Toxic Materials

Toxic materials can enter the body by:

- inhalation—breathing in poisonous or corrosive vapours and dust (most common route by which toxic materials enter the body)
- ingestion—swallowing liquid or solid toxic materials
- direct entry—chemicals entering through open wounds or directly injected through punctures, allowing chemicals access to the bloodstream
- contact—absorbing toxic materials through skin, mucous membrane or eyes.

Since inhalation of vapours or dust is the most common way that toxic materials enter the body, every effort should be made to avoid circumstances that allow this to happen. Any activities that involve use of toxic materials in liquid, vapour or dust form should only be carried out under a fume hood.

Effects of Toxic Chemicals

Toxic effects can be local or systemic, acute or chronic. Local effects are confined to the area of the body that has come in contact with toxic materials; systemic effects occur throughout the body after absorption into the bloodstream. Acute effects are immediate and usually extremely serious or painful. With chemicals that can produce acute effects, poisoning may be suspected when any of the following are evident:

- strange odour on the breath
- discolouration of lips and mouth
- pain or burning sensation in the throat
- unconsciousness, confusion or sudden illness.

By comparison, chronic effects are long lasting and may take many years before becoming evident. Many substances, such as arsenic and mercury, have cumulative effects, meaning that poisoning may occur at lower concentrations through repeated exposures over a period of time. Such substances are sometimes known as insidious hazards.

Insidious substances include carcinogens, teratogens and mutagens. Carcinogens cause cancer in cells. Teratogens interrupt or alter the normal development of a fetus. These include chemicals such as ethanol and mercury compounds, viruses such as rubella, and ionizing radiation. Mutagens increase the rate of mutation of cells or organisms, and include chemicals such as nitrous acid, peroxides and dichromates, as well as certain viruses and radiation.

Insidious Hazards

The most obvious source of insidious chemical hazards is from substances known to have dangerous long-term effects, such as mercury and carcinogens, which are discussed below. These substances can cause damage through direct exposure or through leakage of vapours or fumes from chemical containers. However, even if such chemicals are not intentionally ordered and stored in the schools, insidious hazards can still exist and be easily overlooked. These hazards include:

- leaking gas cylinders
- formaldehyde from biological specimens (if these are still around)
- mixed chemicals that slowly react to form toxic products, particularly mixtures of waste materials
- neglected containers of dried solutions and residues of chemical products from past demonstrations and activities
- residue from chemicals improperly disposed of in the sink drain, resulting in subsequent interactions that cause the formation and release of toxic or other hazardous materials into the laboratory air (for chemicals that can be safely disposed of down the drain, see the Chemical Hazard Information Table in Chapter 9).

Mercury

One relatively well-known hazardous substance is mercury, which can have serious and cumulative effects on the gastrointestinal and central nervous systems. Open mercury evaporates and readily absorbs through the skin and respiratory system. Disposal of mercury and mercury compounds is also a major concern.

Given the hazards of mercury, it is not recommended for use in Alberta schools. Mercury thermometers should no longer be used in schools because of potential breakages and spills. If mercury is still in stock, the following steps need to be taken to manage it more safely:

- Store mercury in plastic bottles under a layer of water or oil.
- Keep the container sealed in a cool, well-ventilated area.
- Avoid opening the container and allowing vapours to escape.
- Wear gloves when handling containers.

Mercury spills from thermometers, thermostats or any other source must be cleaned up immediately and thoroughly, regardless of the size of the spill. Unless spills are promptly and thoroughly cleaned up and the area decontaminated, dangerous exposure to vapours will continue. In the past, the common practice for clean-up was to aspirate or sweep up any visible drops. Often, small droplets hidden in cracks and crevices were inadvertently left behind to evaporate into the atmosphere.

Mercury droplets from 10 to 1000 micrometres in diameter also stick to vertical surfaces and penetrate into porous flooring. In some cases, relatively large amounts of mercury may be left undiscovered after spills. Prompt and thorough clean-up of mercury spills is essential or cumulative exposure to mercury vapours can cause irreparable harm to those working in the area.

In Alberta, the clean-up procedures for mercury spills in schools are determined by local school boards. Some boards may permit school staff to clean-up spills using commercial spill kits, while others specifically restrict clean-up to professionals such as those at Hazmat Clean-Up. Check your school board's policy on mercury spill clean-up before proceeding with the actual process. If board policy allows staff clean-up, use a commercial spill kit that includes components to control vapours; i.e., aspirator, mercury absorbent and vapour absorbent.

Carcinogens

A carcinogen is a chemical, physical or biological substance that is capable of causing cancer. The damaging effects are subtle and imperceptible in the short term, thus carcinogenic substances are another insidious hazard that may be present in the laboratory and chemical storage area. A substance is considered to be carcinogenic if it has been evaluated and rated as a human carcinogen, an animal carcinogen or a potential carcinogen by the American Conference of Government Industrial Hygienists or the International Agency of Research on Cancer. These substances will also be categorized under WHMIS as Class D2.

Health Canada has tabled a list of substances assessed for carcinogenicity on its Web site at http://www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/compli-conform/carcinogenesis-carcinogenese_e.html. The Web site also has links to agencies to enable searches of the most current information. Carcinogenic properties are also indicated in the Chemical Hazard Information Table in Chapter 9.

Actual manifestation of cancer or tumors for most carcinogenic chemicals requires prolonged and often relatively constant exposure. Proper storage of such chemicals in airtight containers reduces this hazard by limiting exposure only to periods of chemical usage. However, the more frequent the use, the greater the exposure, particularly for powdered forms of these chemicals, which can be absorbed through the skin and lungs.

Fewer chemicals have carcinogenic properties compared to other risks, and those that do should be avoided, if possible. Whether to stock and use chemicals with carcinogenic properties will depend on curricular requirements, adequacy of facilities and the ability to safely handle these chemicals with the frequency required. Serious consideration should be given to using alternative chemicals wherever possible.

Corrosive Substances

Corrosive chemicals cause visible, usually rapid damage to human tissue at the site of contact. Often this corrosive quality is due to the reaction of the substance with water or moisture in the tissue. This is the case with strong acids and bases of 1M or greater concentration, nonmetal halides, dehydrating agents, halogens and oxidizing agents. The most serious corrosion hazards come with substances that are in a mist or gaseous state, since they can be readily absorbed through the skin or inhaled into the lungs.

The corrosive properties of chemicals commonly found in schools are identified and discussed in the Chemical Hazard Information Table in Chapter 9.

Minimizing Risks of Toxic and Corrosive Chemicals

Whenever chemicals are used, the onus is on the teacher to assess risks, determine proper handling procedures and convey this information to students before beginning the activity. Handling procedures used for all chemicals, and especially those with greater hazards, should aim to minimize exposure. This can be accomplished through strategies such as the following.

- Do not handle hazardous materials in open container, as vapours, dust and liquids can easily escape during normal handling.
- Do not heat hazardous materials, as smoke and vapour may be released in much greater quantity when material is hot.
- Avoid crushing or grinding solids or unnecessarily transferring powders, which creates dust.
- Use and store hazardous materials only in areas with adequate ventilation. Toxic vapours can rapidly accumulate to dangerous levels in a room, or part of a room, that does not have a constant replacement of fresh air.
- Do not lean over open bottles, as toxic vapours can be concentrated directly above the bottle even in well-ventilated rooms.
- Ensure chemicals are clearly labeled and check these labels every time a substance is used. Odour and appearance are not reliable guides to the toxicity of substances: Dangerous liquids can be clear and odourless, and toxic vapours may have little or no odour, even at dangerous concentration levels.
- Use proper protective gear such as correct clothing, face protection, fume hoods or respirators to prevent skin contact with hazardous materials and inhalation of toxic vapours.
- Do not chew gum, smoke, or store or consume food or beverages in an area where hazardous materials are used. Food, beverages and cigarettes can easily absorb hazardous vapours or be contaminated with unseen toxic dust. Poisons may also be transferred from hands to food or cigarettes.
- Follow proper clean-up procedures after each lab activity is finished. Substances left on benches or in beakers and bottles may expose others to these toxic materials.
- Ensure students wash their hands thoroughly after activities to avoid transferring toxic materials to food they eat.

Insidious hazards could be easily overlooked or ignored, even during routine safety inspections, because they do not have immediately obvious effects. To avoid or reduce these kinds of hazards, consider the following measures.

- Give specific attention to possible sources of insidious hazards during the safety inspection process.
- Prepare an inventory of insidious hazards that must be tended to regularly.
- Provide adequate ventilation in the form of hoods and forced air, as stated in current standards and codes.
- Avoid stock build-up of toxic, flammable or corrosive materials.
- Keep appropriate clean-up agents accessible in case of spills.
- Collect waste materials in separate containers and do not mix.
- Perform diligent and regular housekeeping.

OTHER CHEMICAL HAZARDS

Cryogenic Substances (liquefied/solidified gases)

Cryogenic substances are gases that are maintained in liquid or solid form at extremely low temperatures. The most common cryogens that are readily available to schools are solid carbon dioxide (dry ice) and liquid forms of hydrogen, oxygen, methane and nitrogen.

Cryogens pose several serious hazards. These include:

- *Explosive Pressure*. Cryogenic gas generates enormous pressure when it vapourizes within the container and when released through the valve. In the case of methane gas, for example, the expansion is 630 times that of the equivalent liquid volume.
- *Fire*. Flammable cryogenic substances present the same flammability hazard as their gaseous forms.
- *Embrittlement* of structural materials and human tissues. Most materials experience some degree of embrittlement at temperatures below –50° C. Contact with cryogenic liquids, their gases or the surfaces of their containers can lead to frostbite or more extensive freezing of tissue that can be very destructive. Living tissue can become completely frozen and so brittle that it will shatter on impact.
- *Asphyxiation*. Except for liquid oxygen, expansion of cryogens may displace a sufficient volume of air to cause asphyxiation. This is particularly true of dry ice, which sublimes into carbon dioxide gas and readily displaces normal air, since it is heavier than other atmospheric gases.

The use of cryogenic compounds is not required to meet any specific learner outcomes in Alberta science curricula. Instead, teachers sometimes use these substances to create special effects. Use of cryogens may require submission of a written “Safe Work Procedure” proposal to the Safety Services Department or an equivalent department. Before proceeding with ordering and using these substances, check the regulation requirements with your board office.

Only personnel with the necessary expertise and appropriate administrative approval should handle compressed gases or cryogenic substances, including dry ice. Use by students is not recommended. Anyone choosing to use cryogens should have a thorough knowledge of the characteristics of the substance at the temperatures and pressures being used, and the appropriate safety precautions for handling. They should also know how to recognize and eliminate leaks, and the requirements for short- and long-term storage.

To minimize risks, it is important to take every possible precaution, including the following.

- Use cryogens only in a properly ventilated space to avoid a build-up of gas that may cause fire, explosion or asphyxiation. Adequate ventilation is particularly important to prevent asphyxiation with the use of dry ice.
- Store containers of cryogenics in a cool, well-ventilated space, in an upright secured position, and vent containers properly to avoid explosion. Prolonged storage in a poorly ventilated area will cause metal valves to undergo chemical corrosion. If this occurs, store in a separate cool, dry room away from direct sunlight and sources of sparks or flame.
- Ensure warning signs and the name of the cryogen are all posted in locations where the substance is stored or used.
- Ensure vessels are appropriately labelled and filled only with the liquids that they were designed to hold.
- Perform operations slowly to minimize boiling and splashing.
- If liquid nitrogen is heavily contaminated with oxygen, handle it with precautions suitable for liquid oxygen. The appearance of a blue tint in liquid nitrogen is a direct indication of oxygen contamination.
- Take appropriate precautions when releasing cryogenic gases. If oxygen is used, remember that it does not burn but it does enhance burning of flammable materials, thus open flames or sources of sparks should be removed from the area.
- Ensure that all eyes are protected and all skin is covered by wearing goggles, a face shield, pants and boots, a laboratory coat or apron without pockets or cuffs, and loose-fitting gloves that can be easily removed.
- Remove watches, rings, bracelets and other jewellery.

Compressed Gases

Cylinders of compressed gases should be handled and stored in a similar fashion to cryogenic substances.

Containers used to store gases should meet the National Fire Protection Association (NFPA) standard, prescribed for both Canada and the United States.

Flammable Substances

Generally, substances that are highly flammable, particularly those that are also highly volatile, should not be used by students. If minute amounts are provided for student use, make sure the area is well-ventilated and far from open flames or sparks. Identify and eliminate any unwanted ignition sources that may exist, such as sparks that come with unplugging electrical cords and static electricity. Teacher demonstrations using flammable substances can be done under similar conditions or under the fume hood.

Again, cabinets and containers used to store gases should meet the National Fire Protection Association (NFPA) standard, which is relevant both in Canada and the United States.

Explosive Substances

Concentrated forms of unstable substances that have the potential to explode pose too great a risk to warrant use and should not be kept in schools. Some explosive substances in lower concentrations, such as hydrogen peroxide, are relatively safe. For more information on explosive substances, refer to this group in the "Reactive Nature of Chemicals" table in Chapter 9.

MANAGING THE RELEASE OR SPILL OF TOXIC OR CORROSIVE SUBSTANCES

Deciding how to handle a spill first requires understanding the health hazards associated with the substance. There are three immediate questions that must be answered:

- Is this substance highly toxic or corrosive?
- Does it give off toxic or corrosive fumes?
- Are the fumes potentially explosive?

Answers to these questions can be found in the pertinent MSDS sheets that should be accessible to users at all times, and be reviewed before commencing activities with the materials. For substances that are highly toxic or corrosive—ones that have a health rating of 3 or 4—any spills and releases of these substances must be handled by specially trained professionals who are equipped to deal with such emergencies. This may require evacuation of the school, particularly if toxic fumes are associated with the substance. See Chapter 2 for emergency procedures.

In the case of spills of acids and bases, local action by knowledgeable staff can be taken to neutralize the spill using materials prepared for that purpose. Once neutralized, the products can then be cleaned up and disposed.

Prompt clean-up is also the appropriate measure to deal with manageable quantities of other materials that are not highly toxic or corrosive. All wastes resulting from these cleanups should be contained separately. Placing all spilled or waste chemicals in a general waste bin may result in reactions with other chemicals or wastes placed in the container.

Corrosive Liquids

Less serious spills of corrosive liquids can be handled using the following steps.

1. Put on protective clothing/equipment (face shield, rubber gloves, rubber boots and lab coat) if the spill is concentrated.
2. Contain the spill with asbestos-free vermiculite, clay cat litter (bentonite) or diatomaceous earth.
3. Neutralize the substance. For acids, liberally apply sodium bicarbonate (baking soda) or sodium carbonate (soda ash), or apply a spill kit pillow. For bases, sprinkle boric acid or citric acid on the spill, or apply a spill kit pillow. Test with pH paper to ensure the substance is completely neutralized.
4. Dilute with plenty of water and mop up using an absorbent cloth.
5. Wash contents down the sink and clean spill area with water. Wipe dry with paper towels.

Note: Municipal bylaws and waste regulations may permit some substances to be disposed of through drains. If permitted in your area, wash the material down with plenty of water. Alternatively, absorbent materials (asbestos-free vermiculite or diatomaceous earth) may be used to soak up the solution. The resulting mixture can then be bagged, labelled and sent for disposal.

Flammable Liquids

Small amounts of solvents can be cleaned up as follows.

1. Immediately shut off all ignition sources, and open windows and vents leading directly to the outside for ventilation.
2. Contain and cover the spill with a mineral absorbent such as asbestos-free vermiculite, bentonite or diatomaceous earth.
3. Scoop the contaminated absorbent into a heavy gauge garbage bag or plastic bucket with lid.
4. Wash the spill area with soap and water, using a disposable cloth.
5. Dispose of the contaminated cloth in the same garbage bag.
6. Allow to evaporate under the fume hood.

Other Liquids (excluding mercury)

Water-soluble liquids

1. If necessary, contain with towels, asbestos-free vermiculite, bentonite or diatomaceous earth.
2. Dilute with water.
3. Mop up using paper towels or cloths. Very small spills can be swabbed directly into a sink and flushed with large volumes of water.
4. Check the Chemical Hazard Information Table in Chapter 9 or the MSDS for final disposal details.

Water-insoluble liquids

1. If necessary, contain with towels, asbestos-free vermiculite, bentonite or diatomaceous earth.
2. Cover the spill with mineral absorbent and scoop the contaminated material into a suitable container for disposal.
3. Wash the spill area with water and soap and wipe dry with paper towels.
4. Discard contaminated towels or cloth.
   Check the Chemical Hazard Information Table in Chapter 9 or the MSDS for final disposal details.

Solids

The critical factor in cleaning up solid chemicals is to avoid raising particles into the air and inhaling them.

1. Slowly sweep up granules or powder into a dustpan.
2. Mop up smaller amounts with a damp disposable cloth.
3. Wipe the area clean.
4. Determine appropriate disposal procedures from the Chemical Hazard Information Table in Chapter 9 or the MSDS.