Chemical Safety in Laboratories

Policy

Many chemicals are poisonous, irritating, corrosive, carcinogenic, pyrophoric, or explosive. Some can have more than two of these properties. Chemicals that may be relatively safe when used alone can become dangerous when mixed with other substances, either in a planned experiment or by accident. Therefore, personnel who handle chemicals must consider the hazards and use appropriate controls and procedures.

In Hong Kong, the storage and use of dangerous chemicals are regulated by the Fire Services Department under the Dangerous Goods Ordinance. Personnel exposure to chemicals is regulated by the Labour Department while the disposal of chemical waste is regulated by the Environmental Protection Department.

This document is intended to provide the user of chemicals with general guidelines on safe storage, use and disposal of such chemicals in compliance with regulatory requirements and international standards.

For advice on specialist chemicals e.g. carcinogens, refer to departmental codes of practice or refer to the Safety Office.

Responsibilities

Department Head must:

- ensure staff & students use chemicals responsibly and in line with health and safety requirements.
- notify Safety Office if any chemicals are subjects to Control of Chemicals Ordinance.
- ensure all departmental staff & students know how to react to chemical emergencies.

Supervisors (Academic & Technical) must:

- ensure students under their supervision are familiar with the hazardous properties of the chemicals they handle and provide appropriate instruction, supervision and training to enable them to work safely.

Employees and Students should:

- read and familiarize themselves with chemical MSDS
- report any incident, or condition that is unsafe or potentially hazardous.
- on leaving the University ensure all their chemicals they are responsible for are disposed of or transferred to supervisor.

Safety Office will:

- deliver chemicals and liquid nitrogen from central DG stores
- collect chemical waste
- provide information or safety & health issues relating to chemicals.

Guidance

1. Planning

Users of chemicals should assess the risks associated with the handling of chemicals and reduce the risks by:

(a) choosing the safest chemical which will perform the task;

(b) considering the hazardous properties of chemical and mixtures;

(c) setting up waste disposal arrangements (including minimising waste generated); and

(d) obtaining a review of procedures by supervisor, safety representative or Safety Office staff.

References in the Safety Office Library are available to help and guide users during the planning stage.

2. Purchase of Chemicals

2.1 When acquiring toxic or hazardous chemicals, obtain the smallest quantity required for your work.

2.2 Purchase chemicals, especially corrosive materials (e.g. perchloric acid), in shatter-proof containers such as 'Safe-Break' plastic coated bottles whenever possible. (N.B. with careful cleaning these bottles can then be recycled, offering greater safety in the laboratory).

3. Material Safety Data Sheets

Many chemical manufacturers prepare Material Safety Data Sheets (MSDSs) for their customers. Each data sheet provides detailed information on the physical, chemical, and physiological properties and on recommended control procedures to be used during handling. The Sigma - Aldrich Material Safety Database CD-ROM is available on the University Library Network.

4. Facilities and Equipment

Adequate facilities should be available and the equipment necessary to control the hazards related to specific chemical operations must be obtained before work is started. General requirements for the use of chemicals include the following:

(a) Cabinets and shelving used for chemical storage.

(b) Safety shower and/or eyewash station as applicable.

(c) Fume cupboards for any experiment that produces hazardous quantities of gas, vapour, or airborne particulates (i.e. dust, fume etc.)

(d) Wear safety spectacles when handling small quantities of general laboratory reagents BUT

(e) Use face shields, safety goggles, and gloves when handling larger containers of corrosive chemicals. e.g. Winchesters (2.5 litre) and for larger containers still (e.g. 20 litre) wear liquid proof aprons and acid proof shoes or boots.

(f) Isolate hazardous operations in separate rooms and limit the number of personnel involved.

(g) Select chemicals that are the least hazardous. (Consider not only the occupational exposure limit, but also the volatility (vapour pressure) and other routes of contamination other than via the respiratory system).

(h) Use mechanical aids for all pipetting procedures.

(i) Limit the volume of volatile or flammable materials to the minimum required.

(j) Provide a means for containing the chemical if equipment or containers break or spill their contents.

(k) When transporting chemicals from one area to another, convey the chemical bottles in suitable containers.

(l) When opening bottles which may be under pressure (e.g. formic acid, hydrochloric acid, ammonium hydroxide), cover the bottle with a towel to divert any chemical spray.

(m) Operations involving heating of concentrated perchloric acid must be performed in special fume cupboards with water wash-down facilities.

5. Chemical Storage

Bulk quantities of dangerous goods (DG) should be and are stored in Central D.G. Stores managed by the Safety Office. General requirements for keeping small quantities of chemicals in laboratories are as follows:

(a) Provide fresh air ventilation.

(b) Clearly label the storage area and each container. Container labels must give the chemical name, type of hazard, special precautions, and emergency information where space permits. Common labels are available from the Safety Office. Please click the link to download the Order Form for purchasing.

Alternatively, you can click the link http://www.oshc.org.hk, download the software from Occupational Safety & Health Council and print the label of common hazardous chemicals.

(c) Store heavier items on lower shelves.

(d) Chemicals, particularly those known to decompose with time, should also be marked with the date of receipt.

(e) Carcinogens and highly toxic chemicals should be stored in double containment.

(f) Separate incompatible chemicals by physical barriers. For example, the following classes of chemicals are mutually incompatible: acids, bases, oxidizers, pyrophoric, flammables, toxic, and water reactive

(g) Provide a means to contain spills (e.g. trays).

(h) Limit quantities and observe shelf-life limits.

(i) Only spark-proof refrigerators or those where all electrical contacts (thermostats, lights etc.) are moved externally are suitable for storage of flammable liquids. The storage of volatile, flammable liquids in ordinary refrigerators can lead to and has led to serious explosions.

6. Handling Solid and Liquid Chemicals

(a) Keep the work area clean and orderly.

(b) Do not eat, drink, smoke, apply cosmetics, or store food in the work area. Read all container labels and, if necessary, the MSDSs.

(c) Use required safety equipment. The minimum protective clothing is a laboratory coat and safety glasses; for additional protection, wear gloves and a face shield.

(d) All works should be carried out in an efficient fume cupboard or at least in well ventilated rooms.

(e) Wipe off splashes on the skin first by dry cloth, then immediately with plenty of cold water followed by washing with hot water and soap. Never use organic solvents because of the risk of adsorption.

(f) Thoroughly rinse eyes affected by chemicals with water and immediately afterward take the patients to a medical center. Inform medical personnel the chemical involved.

(g) Immediately remove any items of clothing soaked with corrosive substances.

(h) Wash your hands regularly when working with chemicals, especially before you leave the laboratory.

(i) Breakable vessels must not be carried by the neck and must be supported from below. They must be transported in baskets or carrying frames over longer distances such as up and down stairs, or along corridors.

7. Flammability Hazards

There is a high fire risk in many laboratories because of the storage and handling of flammable liquids. It is, therefore, essential that the means of escape from the workplace is not obstructed. The following precautions should be observed:

- Do not use an open flame to heat a flammable liquid.
- Use an open flame only when necessary and extinguish it when it is no longer actually needed.
- Before lighting a flame, remove all flammable substances from the immediate area. Check all containers of flammable materials in the area to ensure that they are tightly closed. Tell your colleagues that you intend to use naked flames.
- Quantities of flammable substances in laboratories should be kept to a minimum. The maximum storage is 20 litres of any one substance but not more than 40 litres in aggregate. When not in use solvents should be kept in suitable fire resistant cabinets.
- Empty containers which have held flammable materials will contain explosive quantities of vapour if the container is not washed out or ventilated.

8. Highly Reactive Chemicals and Unstable Chemicals

8.1 Highly Reactive Chemicals

Some chemicals react in combinations with others at ordinary temperatures, sometimes with great violence. This reactivity may be manifested as a corrosive effect, or as the liberation of a large amount of heat or even an explosion when the chemical comes into contact with others or is exposed to moisture or air.

e.g.

- Powerful oxidising agents such as perchloric acid, nitric acid or chlorine react violently with easily oxidisable materials such as hydrocarbons.
- Metal alkyls such as triethylaluminium burst into flames on exposure to air.
- The alkali metals react vigorously with water.

Incompatible chemicals are listed in the Appendix I.

Although not themselves explosive, some compounds can cause their containers to burst because of the high pressure of gas generated in them through, e.g. hydrolysis, or decomposition.

e.g. Chlorides of aluminum, titanium and silicon, formic acid

8.2 Unstable Chemicals

Some chemicals can explode if heated or subjected to mechanical shock.

e.g. Metal acetylides, azides, azo and diazo compounds, chlorates and perchlorates, highly nitrated organic compounds, nitrogen halides, organic peroxides, and organic salts of per-acids.

8.3 Ethers and Other Peroxidisable Chemicals

Peroxidisable chemicals, when in the presence of oxygen and stored for long periods of time, or when exposed to sunlight, can form unstable peroxides. These peroxides may explode if the container is shaken or heated. Examples of peroxidizable materials are diethyl ether, tetrahydrofuran, dioxan, alkali metals, olefins, and vinyl monomers. The precautions are:

- Store in dark containers away from direct sunlight; in a storage cabinet for flammable liquids.
- The date of opening should be marked on the bottle.
- Chemicals should be tested for the presence of peroxide regularly and always prior to use.

8.3.1 Detection of peroxides

To 1 mL of a 20% by weight of aqueous solution of potassium iodide add 1 mL of sample in a small test tube. After vigorous mixing and shaking a change of colour in the aqueous layer from colourless to yellow is an indication of a low level of peroxide in the sample. A brown-red colour is taken as an indication of high peroxide content. If no colour change is observed, peroxides are considered to be absent.

Alternatively, use Merck peroxide test strip or Whatman starch-iodide test strip.

8.3.2 Removal of peroxides

(a) With iron (2) sulphate.
Shake the solvent with a freshly prepared solution of iron (2) sulphate (5 g iron (2) sulphate dissolved in 20 ml of water/litre of ether) prior to further use. This procedure must be repeated until no further peroxides can be detected in the solvent with the peroxide test.

(b) With aluminum oxide, activated, neutral
If the solvent is dry, 30 g. of aluminum oxide (in a column of 20 mm diameter) is sufficient to remove the peroxides from 250 ml of diethyl ether. This method is often slower and more expensive than method (a); however, the eluted material is often ready for use without further purification.

Any peroxide materials that remain on the alumina column should be destroyed by passing a saturated solution of iron (2) sulphate through the column.

8.4 Others

Some chemicals which have explosive properties when dry need to be kept wet or moist for safe storage:

e.g. Dinitrophenols
2,4-Dinitrophenylhydrazine
4-Fluoro-3-nitrophenylhydrazine
Hexanitrodiphenylamine
Picric acid
Picryl chloride
2,4,6-Trinitrobenzenesulphonic acid

For these chemicals, the following safety procedures should be taken:

- Inspect containers regularly and add water as necessary.
- When the contents have completely dried, immerse the container in water, with a small amount of detergent, for at least 24 hours.
- With the container still underwater, slowly unscrew the cover, allowing water to wet the screw threads.
- Once the closure is loose, remove the container from the water bath, remove the cover and add the required amount of water.

9. Handling Compressed Gases

Compressed gas cylinders used in the laboratories contain a tremendous amount of energy which can be violently released under certain conditions. The flammable and/or toxic nature of some of the gases could pose a serious potential hazard if accidentally released. Compliance with the following guidelines can greatly reduce these risks.

(a) Each cylinder must bear a label identifying its contents. Make sure you know the contents and characteristics of the gas before use.

(b) Use gases only in an area with adequate ventilation.

(c) A cylinder should be moved only with a suitable trolley, never rolled or dragged.

(d) A cylinder must not be transported with the regulator attached.

(e) In the laboratory cylinders must be strapped to the wall, bench top or other firm support.

(f) Cylinders should not be subjected to temperatures higher than 50°C or to a direct flame.

(g) Cylinders containing oxygen should be kept away from flammable gases or large quantities of flammable liquids.

(h) Use proper tools to tighten the regulator and to open the cylinder main valve.

(i) Check leakage of all joints after the completion of the connection, swap connections with a soap solution and look for bubbles.

(j) Never tamper with safety devices in a cylinder, regulator or valve.

(k) The cylinder main valve and regulator should be shut off when it is not in use.

(l) If the gas is corrosive, the cylinder main valve shall be worked frequently to prevent it from corroding and sticking. Regulator and valves shall be removed and flushed with dry air or nitrogen after use, not just left on the cylinder.

(m) The date required for a pressure test of the cylinder shall be noted for all privately owned cylinders, as they are required by law to be pressure tested at regular intervals.

10. Precautions for Cryogenic Gases

(a) Avoid contact with both the liquid and the gases as they can cause frostbite. Do not touch uninsulated piping.

(b) Wear loose-fitting thermal glove, goggles and/or face shield and closed shoes.

(c) Work in a well ventilated area. Liquidfied gas volatilises and expands rapidly (e.g. nitrogen expands almost 700-fold).

(d) Never attempt to prevent vapours from escaping from cylinders of liquefied, cryogenic gases. Since they are not at thermal equilibrium, vapour is produced as the liquid boils and, if not vented to the atmosphere, could produce excessive pressures.

(e) Use only the special (usually metal) tubing designed for use with these gases. Do not improvise with plastic or rubber tubing.

(f) Be aware that oxygen enrichment and a fire hazard can result from the condensation of oxygen (boiling point -183°C) from the air onto piping cooled by liquid nitrogen (boiling point -196°C).

(g) If a glass dewar flask is used as a container for small quantities of liquid nitrogen, the exposed glass part of the flask should be taped to minimize the flying glass hazards in case of implosion or explosion.

(h) If a domestic thermos flask is used as a container for small quantities of liquid nitrogen, the integrity of the plastic sealing ring of the thermos should be checked regularly to ensure that no liquid nitrogen can get into the space between the thermos and the outside container. In every case ensure that holes are drilled in the base plate to allow gas to escape.

(i) Avoid contact with the liquid nitrogen directly. Always wear gloves (leather or CRYO-GLOVES) when handling anything that is in contact with liquid nitrogen.

(j) Protect your eyes with safety spectacles with side shields, safety goggles or face shield. Eyes can be damaged even by the cold gas issuing from liquid nitrogen.

(k) When charging a warm container or when inserting objects into the liquid, perform the operation slowly to minimize boiling and splashing.

(l) If skin contacts liquidfied cryogenic gases, thaw the burned area slowly in cold water. Do not rub.

Precautions for Liquid Gas Containers (LGC)

Liquid gas containers are portable containers for the transport and storage of refrigerated liquid gases. They incorporate self pressurizing equipment and provide a complete, self-contained gas supply system. Only experienced and properly instructed persons should handle liquid gas containers. Please click the link for Safety Information for LGC.

11. Unattended Experiment and Working after Normal Hours

Laboratory operations involving chemicals are frequently carried out continuously or overnight. It is essential to plan for interruptions in utility services such as electricity, water and inert gas supply. Operations should be designed to be safe, and plans should be made to avoid hazards in case of failure.

Experiments involving hazardous chemicals or hazardous procedures should not be undertaken by a worker who is alone in a laboratory.

See Code of Practice: "Work Outside Normal Working Hours"

12. Emergency Response for Chemical Spill

12.1 Introduction

Before handling hazardous chemicals consideration should be given to the action that needs to be taken in the event of spillage, and a plan of action prepared. The spillage kit is part of the action plan, the other part relies on the users of chemicals to determine in advance what their correct response should be.

12.2 Action

12.2.1 General

(a) On discovery of significant spillage, the affected area should be vacated.

(b) At least two people should work to deal with spill.

(c) If liquid is flammable, all sources of ignition should be isolated or removed.

(d) Area should be ventilated by opening windows, turning on fume cupboards, etc.

(e) Work on spill should be tackled from side closest to exit.

12.2.2 Protective Clothing

(a) Wear gloves and laboratory coat.

(b) If chemical is toxic by inhalation, a respirator fitted with appropriate filter should be used.

(c) In extreme cases where the chemical is extremely toxic and volatile the building should be evacuated and expert assistance offered to the Fire Services when they arrive.

12.2.3 Procedure:

(a) Use the 3M chemical absorbent to form a dam around the spillage and then cover the spillage adequately until the spill is completely absorbed.

(b) Fill the absorbent into a polythene bag and attach a waste label. If there is doubt about the reactivity of the chemical with the bag, the waste should be placed in a suitable second container.

(c) Call the Safety Office 28592402 for collection of the waste.

12.2.4 Warning

No spills or wastes should be flushed down a drain except where it is clearly known that it is permissible and no harm to plumbing or to the environment will result.

N.B.: 3M chemical sorbent is suitable for treatment of concentrated acids and alkalis, aqueous solutions, organic solvents and thin paraffin oils.

12.2.5 Clean-up

Small spills can usually be cleaned up safely by the employees involved. Employees must be trained to handle cleanup of small spills. Material for clean up of common chemical spills are available from Safety Office. Keep used material in a waste container.

If a spill involving large amounts of hazardous chemicals occurs:

(a) Alert your fellow workers immediately.

(b) Confine spill if safe to do so.

(c) Open the windows and switch on the fume cupboard to ventilate the area.

- turn off all burners;
- switch off all electrical equipment which have hot surfaces, (e.g. hot plate) or/and generate electric spark (e.g. brush type motor) NOT in vincity to the spill and
- do NOT switch on/off or unplug any electrical equipment.

(d) Call nearby Fire Brigade, Security Guard and Safety Office.

(e) If your clothes are contaminated, remove them immediately.

(f) Evacuate the room. Make sure no body stays behind. Close the door(s) of the laboratory after you leave.

(g) Keep at a distance from the laboratory but remain in sight of the entrance, forbid unauthorized entry to the laboratory and wait for the arrival of the fire brigade.

Clean up small spill

12.3 Mercury

(a) Dam off the contaminated area and collect all the droplets by means of Hg Absorb sponge and dropper.

(b) Use Hg Absorb sponge to amalgamate mercury residue.

(c) Cover fine droplets in non-accessible cracks with Hg Absorb powder.

(d) Collect all reacted mercury into a polyethylene bag with a "waste" label attached.

(e) Inform the Safety Office (2859 2402) to collect the waste.

N.B.: Remember mercury is toxic and volatile. Therefore, mercury spills should be cleaned up immediately and thoroughly.

12.4 Solid Spills

Solid spills are usually easily dealt with using the dust pan and brush provided. However, care is required to prevent the generation of air borne dust so it may be necessary to damp the spillage before sweeping using an appropriate liquid, e.g. water, non-flammable and non-toxic solvent, etc.

12.5 Spill Kit Contents:

(1)	Nitrile Rubber glove	1 pair
(2)	Disposable plastic glove	some
(3)	Disposable plastic bag	some
(4)	Absorbent pad	6 pcs.
(5)	Econo Mercury Spill Kit	1 set
(6)	Dust pan and brush	1 set
(7)	Safety Glasses	1 pair
(8)	Waste label	some

12.6 Conclusion

These guidelines are brief and are designed to give a quick and easy reference. However, in circumstances outside these guidelines, please call Safety Office on 2859 2402.

13. Emergency Response in a Fire

13.1 Fire Action

If you discover a fire:

- Raise the alarm by operating the nearest fire alarm point.
- Tackle the fire with the appliances provided, taking no personal risks BUT
- If your efforts are not immediately successful leave the building.

If you hear the continuous alarm:

- Leave the building immediately.
- Close doors behind you.
- Go directly to your assembly point (which your department should inform you).
- Do not stop to collect personal belongings.
- Do not use lifts.
- Do not re-enter the building until authorised.

14. References:

📖 Safety Manual - Hong Kong University of Science and Technology

📖 Safe Practices in Chemical Laboratories, Royal Society of Chemistry

📖 Hazards in Chemical Laboratory, L. Bretherick, Royal Society of Chemistry.

📖 Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council.

Appendix I:

Table 1 Partial List of Incompatible Chemicals (Reactive Hazards)

Substances in the left hand column should be stored and handled so they cannot possibly accidentally contact corresponding substances in the right hand column under uncontrolled conditions, when reactions may occur.

Acetic acid	Chromic acid, nitric acid, peroxides, and permanganates.
Acetic anhydride	Hydroxyl-containing compounds, ethylene glycol perchloric acid.
Acetone	Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide.
Acetylene	Chlorine, bromine, copper, silver, fluorine, and mercury.
Alkali and alkaline earth metals, such as sodium, potassium, lithium, magnesium, calcium	Carbon dioxide, carbon tetrachloride, and other chlorinated hydrocarbons. (Also prohibit water, foam, and dry chemical on fires involving these metals – dry sand should be available.)
Aluminium powder	Halogenated or oxygenated solvents.
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, and hydrogen fluoride.
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organics, or combustibles.
Aniline	Nitric acid, hydrogen peroxide.
Bromine	Ammonia, acetylene, butadiene, butane, and other petroleum gases, sodium carbide, turpentine, benzene, and finely divided metals.
Calcium oxide	Water.
Carbon, activated	Calcium hypochlorite, other oxidants.
Chlorates	Ammonium salts, acids, metal powders, phosphorus, sulfur, finely divided organics, or combustibles.
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohol, and other flammable liquids.
Chlorine	Ammonia, acetylene, butadiene, butane, other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, and finely divided metals.
Chlorine dioxide	Ammonia, methane, phosphine, and hydrogen sulfide.
Copper	Acetylene, hydrogen peroxide.
Fluorine	Isolate from everything.
Hydrazine	Hydrogen peroxide, nitric acid, any other oxidant, heavy metal salts.
Hydrocarbons (benzene, butane, propane, gasoline, turpentine, *etc*.)	Fluorine, chlorine, bromine, chromic acid, conc. nitric acid, peroxides.

Table 1 *Continued*

Hydrogen cyanide	Nitric acid, alkalis.
Hydrogen fluoride	Ammonia, aqueous or anhydrous.
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials, aniline, nitromethane.
Hydrogen sulfide	Fuming nitric acid, oxidizing gases.
Iodine	Acetylene, ammonia (anhydrous or aqueous).
Mercury	Acetylene, fulminic acid*, ammonia.
Nitric acid (conc.)	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrogen cyanide, hydrogen sulfide, flammable liquids, flammable gases, and nitratable substances, fats, grease.
Nitromethane, lower nitroalkane	Inorganic bases, amines, halogens, 13X molecular sieve.
Oxalic acid	Silver, mercury, urea.
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, or gases.
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils, dehydrating agents.
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold.
Phosphinates	Any oxidant.
Phosphorus (white)	Air, oxygen.
Potassium chlorate	Acids (see also chlorates).
Potassium perchlorate	Acids (see also perchloric acid).
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid.
Silver	Acetylene, oxalic acid, tartaric acid, fulminic acid*, ammonium compounds.
Sodium	See alkali metals (above)
Sodium nitrite	Ammonium nitrate and other ammonium salts.
Sodium peroxide	Any oxidizable substance, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethy acetate, methyl acetate, and furfural.
Sulfuric acid	Chlorates, perchlorates, permanganates.
Thiocyanates	Metal nitrates, nitrites, oxidants.
Trifluoromethane sulfonic acid	Perchlorate salts.

* Poduced in nitric acid – ethanol mixtures.

Table 2 Partial List of Incompatible Chemicals (Toxic Hazards)

Substances in the left hand column should be stored and handled so they cannot possibly accidentally contact corresponding substances in the centre column, because toxic materials (right hand column) would be produced.

Arsenical materials	Any reducing agent*	Arsine
Azides	Acids	Hydrogen azide
Cyanides	Acids	Hydrogen cyanide
Hypochlorites	Acids	Chlorine or hypochlorous acid
Nitrates	Sulfuric acid	Nitrogen dioxide
Nitric acid	Copper, brass, any heavy metals	Nitrogen dioxide (nitrous fumes)
Nitrites	Acids	Nitrous fumes
Phosphorus	Caustic alkalis or reducing agents	Phosphine
Selenides	Reducing agents	Hydrogen selenide
Sulfides	Acids	Hydrogen sulfide
Tellurides	Reducing agents	Hydrogen telluride

* Arsine has been produced by putting an arsenical alloy into a wet galvanized bucket.