SAFETY
IN
SCIENCE LABORATORIES

EDUCATION DEPARTMENT
HONG KONG
1994

CONTENT

PREFACE

This pamphlet is a revised edition of the one published in 1990. There have been some changes and additions. The aim of this pamphlet is to enhance the standard of safety in school laboratories by minimizing risks and dealing effectively with any accidents which may occur. It must, however, be emphasized that the advice and information offered in this pamphlet are inevitably not exhaustive and do not preclude the need for exercising care and good judgement at all times in safe-guarding against accidents.

The Education Department gratefully acknowledges the assistance given by the Department of Health, Government Laboratory, Environmental Protection Department, Fire Services Department, Agriculture and Fisheries Department, Customs and Excise Department, Electrical & Mechanical Services Department, University of Hong Kong, Hong Kong Examinations Authority, St. John Ambulance Association, Hong Kong Red Cross and members of CDC Subject Committees.

For enquiries, schools are invited to contact the Physical Sciences Section and the Biological Sciences Section of the Advisory Inspectorate, Education Department.

EDUCATION DEPARTMENT
HONG KONG
1994

INTRODUCTION

In recent years, science teaching in secondary schools has undergone rapid changes towards a much greater emphasis on the experimental approach. There is therefore an increasing importance for science teachers, laboratory technicians and students to pay attention to safety precautions when working in the laboratory. In addition the attention of teachers and laboratory staff should be drawn to the need for regular maintenance of equipment and proper storage of chemicals. Students should be alerted to potential hazards so that these may be avoided. However, while known hazards can be guarded against there is always an element of unforeseen danger which calls for proper attitudes to laboratory work and the setting of good examples by teachers.

Teachers must be thorough in preparation and alert in supervision. Furthermore, certain pre-requisites to safety are fundamental, and teachers and laboratory staff need to stress their importance continually by both word and example. These pre-requisites are:—

1. cleanliness,
2. tidiness,
3. laboratory discipline,
4. constant supervision of students' activities in the laboratory,
5. the prohibiting of irresponsible 'experimenting' or 'playing about' with chemicals to see what may happen,
6. drawing attention to the potential danger in every electrical socket, and
7. proper storage of chemicals and apparatus.

Science teachers and laboratory staff must at all times remember the great responsibility they have towards students in their charge during practical work and ensure that all precautions consistent with common sense are continually observed.

All laboratories should have notice boards, which should be installed in prominent positions and on which posters on laboratory safety and regulations can be displayed. A clear instruction should be prominently displayed so that in an emergency a telephone call to 999 can be made immediately. The telephone number of the Education Department should also be indicated on the notice board.

In addition to printed notices, verbal instruction is of vital importance in keeping the subject of safety continually in the minds of laboratory staff and students. Senior science teachers should, therefore, arrange at least one meeting each term at which discussions among all science teachers and laboratory staff can take place on matters concerning laboratory safety.

The subject of laboratory discipline should be introduced into normal lessons whenever there is a need, but it is recommended that there should be at least one period per science subject per class set aside at the beginning of each school year for teachers to stress the importance of safety precautions to all students. Such instructional periods should be noted in a record book kept in the laboratory.

As far as practicable, laboratory work involving the use of chemicals should be designed on a test-tube or semi-micro scale to enhance laboratory safety and to reduce environmental pollution.

GENERAL PRECAUTIONS

The following points are some general precautions concerning laboratory safety. These may serve as guidelines from which schools can work out a set of laboratory rules to be followed by every laboratory user.

A. Students' discipline in the laboratory

1. Students should follow strictly the instructions given by the teacher.
2. Students should not enter the laboratory unless a teacher is present.
3. Students should not remove anything from the laboratory without permission.
4. Students should not rush around or play in the laboratory.
5. Experiments under way should not be left unattended.
6. Laboratory reagents and chemicals should be returned to the appropriate places immediately after use, with their labels facing the front.
7. Students should immediately report all accidents and breakages to their teacher.
8. Students should not suck fingers or pencils when in the laboratory since these may be contaminated with chemicals as well as germs which may cause infectious diseases.

B. Personal precautions to be taken by all laboratory users

1. Eating, drinking and smoking are strictly forbidden in the laboratory and preparation room.
2. Wear protective clothing (e.g. laboratory gown) in the laboratory. Torn or ragged clothing can be dangerous instead of protective.
3. Wear eye protection (e.g. safety spectacles) in the laboratory whenever there is any risk to the eyes.
4. Wear protective gloves when required to handle corrosive or hazardous chemicals; wear a face shield or respirator if necessary.
5. Special care is needed when working with many chemicals which have known hazards. It is important to understand the hazard in each case and to take the proper precautions.
6. Wash hands after experiments, especially those involving the use of chemicals, living organisms, and radioactive substances.
7. To avoid the possibility of allergic reactions, care should be taken to ensure that pollen and fur are not unnecessarily distributed throughout the laboratory.

8. Long hair must be securely tied.
9. Pipette fillers should be used in transferring liquid chemicals which are toxic in nature.

C. Laboratory Management

1. The laboratory and the preparation room should at all times be kept clean and tidy. Broken glass and chemical spillages must receive immediate attention.
2. All exists and passages should be kept clear and none of the exit doors should be locked when the laboratory is in use. The escape routes should be made known to everybody in case of an emergency.
3. As far as possible, laboratories (especially the chemistry laboratory) should not be employed for non-teaching purposes.
4. The lighting in the laboratory and preparation room should be good and sufficient. Working under poor lighting could be dangerous.
5. Every reagent bottle should be clearly labelled. All old and blurred labels should be replaced without delay.
6. Dangerous chemicals must be securely stored in strong cupboards under lock and key and away from heat sources. Such chemicals should be inspected regularly. A detailed record of them should be kept.
7. The fume cupboard is constantly required for carrying out laboratory work which may generate unpleasant or toxic fumes and gases. It should therefore be given proper maintenance and its working surface should be kept tidy and clean at all times. It should not be used as a storage space for glassware, apparatus and chemicals.
8. Food or drink should not be kept in the laboratory except for experimental purpose.
9. It is essential to ensure that there is no panic in case of emergency. Everyone should remain calm and the appropriate measures should be taken quickly and efficiently.
10. Before leaving the laboratory unattended for long periods of time, all water taps, electrical switches and gas mains should be turned off and all doors should be locked.
11. Safety spectacles (or goggles) and face shields should always be kept in good condition. Scratched or defective safety spectacles (or goggles) and face shields should be replaced without delay because they may affect visibility and cause strain to the eyes or fail to serve their protective function. Dirty safety spectacles (or goggles) and face shields should be cleaned with a detergent or disinfectant (e.g. diluted Savlon) as appropriate.

HAZARDOUS CHEMICALS AND THEIR STORAGE

Hazardous chemicals may be defined as those which may, under certain circumstances, cause injury to persons or damage to property. Chemicals may be hazardous because they are corrosive, flammable, irritant, toxic, harmful, oxidising, explosive or carcinogenic. Many hazardous chemicals may involve more than one hazard.

Good housekeeping, regular inspection as well as clear and exact labelling are essential for minimizing accidents resulting from the storage of chemicals.

The following general precautions should be closely observed when storing chemicals:

1. Hazard warning symbols should be displayed on reagent bottles and other containers of hazardous chemicals. More than one symbol can be used for chemicals with more than one hazard. Some hazard warning symbols in common use are shown in Appendix 1.
2. In general, chemicals, especially hazardous chemicals, should not be stored on high shelves where there would be a risk of dropping when taking them down for use.
3. The storage area for chemicals should be provided with sufficient fresh air ventilation.
4. The preparation room and storeroom should not be accessible to students.
5. Where school laboratories have no adjacent preparation room/ storeroom, there is an increased obligation on the supervisor, principal, science teachers and laboratory staff to ensure that dangerous chemicals are safely stored in locked cupboards to which students have no access.
6. Chemicals which have to be kept in suitable 'immersion' liquids (e.g. phosphorus in water, sodium in paraffin oil) should not be kept on the same shelf where they could be confused.
7. Chemicals which could combine to produce fumes, a fire or an explosion must not be kept close to each other.
8. Volatile liquids must be stored in a cool place, away from sunlight or heat sources. Their containers should never be completely filled.
9. Flammable liquids should never be kept on open shelves, nor should they be readily accessible to students. They should be stored in a locked cupboard away from any heat source.
10. Volatile flammable liquids should never be placed in domestic refrigerators. If placed in refrigerators with thermostat controls and door-switch which may spark in operation, these liquids can give out vapours which may be ignited by the sparks causing explosion.

11. Main stock of concentrated sulphuric, nitric and hydrochloric acids, 0.88 ammonia, and flammable liquids should be stored as near to floor level as possible.
12. Chemicals which readily absorb moisture must be kept in tightly sealed containers or desiccators, e.g. sodium peroxide, phosphorus(V) oxide, phosphorus(V) chloride, aluminium chloride, calcium chloride, calcium carbide.
13. All chemical supplies must be correctly arranged, recorded in stock books, effectively labelled and regularly inspected at all times.

In the following sections, some hazardous chemicals commonly encountered in the laboratory are described and the appropriate precautions outlined, followed by some guidelines on their storage. These sections may serve as reference for science teachers, laboratory staff and students engaged in experimental work.

A. Corrosive Chemicals

Special care is called for when storing or using the following corrosive substances:

Aluminium chloride, ammonia, bromine, benzoyl chloride, chlorine, ethanoic acid, ethanoic anhydride, ethanoyl chloride, hydrobromic acid, hydrochloric acid, iodine, methanal, methanoic acid, nitric acid, phenols, phosphorus chlorides, potassium hydroxide, sodium hydroxide and sulphuric acid.

Most of the above are injurious especially on prolonged contact with the skin and should normally be handled with the gloves on. Any spillages adhering to the skin should immediately be washed with plenty of water.

Storage of Corrosive Chemicals

Chemicals	*Storage*
Aluminium chloride, anhydrous	Cool and dry, in a well-sealed container.
Ammonia (0.88)	Cool and at floor level. Isolate from halogens and acids. Great care should be taken when opening stock bottles.
Bromine	Store apart from other materials in a cool place. Stopper the bottle tightly after use, and open with caution in a fume cupboard. (Fresh purchase should be in the form of ampoules which are more convenient to store).

Chemicals	*Storage*
Hydrochloric acid, concentrated	Store at floor level in a well ventilated room. Isolate from oxidising agents, particularly nitric acid, chlorates and methanal (formalin or formaldehyde).
Hydrogen peroxide	Keep in brown bottles, away from heat and sunlight. Hydrogen peroxide is fairly stable when pure but may decompose explosively, particularly in contact with dust particles or finely divided metals. It is safe to store when diluted.
Nitric acid, concentrated	Store at floor level in a well ventilated room. Isolate from reducing agents, metals and strong alkalis. See also Oxidising Chemicals.
Methanal (formaldehyde) and formalin	Store in a well ventilated room. Isolate from concentrated hydrochloric acid. See also Irritant Chemicals.
Phosphorus(V) chloride and Phosphorus(III) chloride	Store in well sealed containers away from moisture and heat.
Potassium hydroxide (solid) and sodium hydroxide (solid)	Store dry in well sealed containers. Keep away from acids.
Sulphuric acid, concentrated	Store at floor level, away from strong alkalis, chlorates, perchlorates and permanganates.

B. Flammable Chemicals

Flammable chemicals may be gases, liquids or solids. The use of such chemicals in science laboratories poses a fire and sometimes an explosive hazard.

The following precautions should be taken:

1. No smoking, no flames and no electric hot-plates.
2. Fire-fighting equipment must be at hand.
3. Flammable chemicals must not be poured down the drain.

(*a*) Flammable gases—these include hydrogen, hydrogen sulphide, carbon monoxide, Town gas, LP gas, and hydrocarbon gases. Most of these also form explosive mixtures with air or oxygen.

(*b*) Flammable liquids—flammable liquids not only burn in air but their vapours also form explosive mixtures with air. These include benzene, carbon disulphide, dimethylbenzene (xylene), ethoxyethane (diethyl ether), ethanol, ethyl ethanoate, methanol, methylbenzene (toluene), propanone (acetone) and petroleum ether.

In general, all organic liquids should be treated as flammable and appropriate safety measures should be taken when working with them.

Storage of Flammable Volatile Liquids

Flammable, volatile liquids must be stored in a cool place (NOT in a refrigerator) at floor level, away from heat sources and direct sunlight. Their containers should never be completely filled. It should be noted that carbon disulphide and ethoxyethane (diethyl ether) can ignite when the vapour or liquid comes into contact with a hot surface.

Great care should also be taken when storing ethoxyethane (diethyl ether). Ether peroxide can be formed by air oxidation of diethyl ether. Ether peroxide is highly explosive. Explosion may result when 'old' samples of diethyl ether are distilled or evaporated to a small volume, due to formation of ether peroxide. If in doubt, test with potassium iodide solution. A yellow or brown colour indicates the presence of the peroxide. Diethyl ether should not be kept for a long time in half-empty bottles.

Ethanol (ethyl alcohol) should not be stored together with kerosene or thinner in the laboratory, or in any other room within the school premises, including the dangerous goods store.

(*c*) Flammable solids—some solids burn upon exposure to air, water or heat. Some ignite spontaneously when subjected to friction, or give off flammable gases upon contact with water and moisture. Flammable solids in this category include aluminium and magnesium powder, phosphorus (yellow or white), potassium, sodium, sulphur and calcium carbide.

Storage of Flammable Solids

Chemicals	*Storage*
Alkali metals: potassium, sodium	Cover with paraffin oil in well sealed glass bottles. Keep bottles in metal containers and store dry. Old stocks of potassium and sodium (especially the former), which may appear yellow due to the formation of superoxides, are liable to explode upon friction or shock. Hence, they should not be used for practical work or cut into small pieces with a knife. As general guide, it is advisable (*a*) to purchase these metals in only small quantities, (*b*) to keep no more than 100 g of each metal in the laboratories, (*c*) to date stamp the containers of these metals

Chemicals	*Storage*
	upon arrival and (*d*) to check the stock of these metals regularly.
Metal powders: Aluminium powder and magnesium powder	Keep dry. Isolate from strong oxidising agents.
Phosphorus (yellow or white)	Cover with water in a well sealed container. Isolate from other chemicals.
Calcium carbide	Calcium carbide reacts with water to generate heat and ethyne which forms an explosive mixture with air. Calcium carbide should be kept dry by storing in a tightly sealed container and away from heat.

C. Irritant Chemicals

Irritant chemicals usually refer to those chemicals which can cause by themselves or their vapours inflammation through immediate, prolonged or repeated contact with the eyes, skin or respiratory system. Plastic gloves should be worn when handling these chemicals and particular care should be taken when opening containers of these chemicals.

1. Halogens are strong irritants to the eyes and skin. Experiments involving halogens should be carried out inside a fume cupboard. Halogens are also toxic. See also Toxic Chemicals.
2. Phenol is corrosive and can blister the skin if touched. Its vapour is also very toxic. See also Toxic Chemicals.
3. Both the liquid and the vapour of nitrobenzene irritate the eyes. The chemical is also toxic. See also Toxic Chemicals.
4. Glacial ethanoic acid (glacial acetic acid) causes burns in the skin. Its vapour irritates the respiratory system, skin and eyes.
5. Vapour of Millon's reagent irritates the respiratory system. The reagent is also a harmful chemical. See also Harmful Chemicals.
6. Methanal (formaldehyde) vapour irritates the respiratory system and eyes. The liquid and its solution (formalin) irritate the skin and eyes. See also Harmful Chemicals.
7. Vapours of phenylamine (aniline) and its hydrochloride irritate the eyes. See also Harmful Chemicals.
8. Trichloromethane (chloroform) and its vapour irritate the eyes. The chemical is also toxic. See also Toxic Chemicals.

Storage of Irritant Chemicals

Irritant chemicals should be stored cool and inside a well ventilated room.

D. Toxic Chemicals (Poisons)

Poisoning does not always take place through the mouth. It can also result from inhalation, or from absorption through the skin. Toxic chemicals are substances which if inhaled, ingested or penetrated through the skin, may involve serious, acute or chronic health risk and even death. For the sake of safety, all chemicals should be regarded as poisonous and be treated with due respect. Chemicals should never be tasted. Teachers should impress upon students the dangers of eating food in the laboratory, and using laboratory glassware as drinking utensils. Students should be instructed to wash their hands before leaving the laboratory. Students should also be made aware of the danger associated with the use of the following substances:

1. Cyanides are the most potent of all poisons: a few grains taken into the body may cause death rapidly.
2. Arsenic and arsenic salts are extremely poisonous: their absorption can cause death very quickly.
3. Mercury, a cumulative poison, also yields a vapour which is poisonous in as low a concentration as one in a hundred million. Any distillation involving mercury, if it has to be done at all, must be performed in a well ventilated fume cupboard which is an essential fitting in every Chemistry or Integrated Science laboratory. In this context, the preparation of oxygen by heating mercury(II) oxide is not recommended. Since mercury does produce a vapour, every precaution should be taken to avoid spilling, thereby minimizing the risk of mercury poisoning. Any spills should be picked up at once. As far as possible any drops spilt on the floor or the bench should be collected by means of a glass capillary tube attached to a vacuum pump (or water pump) via a suitable trap (e.g. a filter flask). Any residual drops left in the crevices should then be immediately covered with flowers of sulphur. Mercury salts are also highly poisonous.
4. Ethanedioic acid (oxalic acid) and ethanedioates (oxalates) are toxic by inhalation and ingestion. Teachers and students are strongly recommended to use a pipette filler if aliquots of these are to be used volumetrically.
5. Halogens are highly toxic by ingestion and inhalation. Experiments involving halogens should be performed in a fume cupboard.
6. Cadmium and its compounds are highly poisonous and should be handled with great care. They should neither be inhaled nor ingested.
7. Lead and its compounds are toxic. There is now clear evidence of the many harmful effects resulting from ingestion or inhalation of small

quantities. It should be noted that lead poisoning is long term and cumulative. Science students, in common with the rest of the population, are exposed to lead in the atmosphere (e.g. presence of lead in car exhaust), and from many other sources. Every care should be taken not to add appreciably to the body burden of lead as a result of experimentation in the laboratory.

8. Phenol is very toxic as a vapour if inhaled and when absorbed through the skin.
9. Nitrobenzene is poisonous by skin absorption and ingestion. Its vapour is harmful if inhaled. It is flammable.
10. Ethoxyethane (diethyl ether)—ingestion of ethoxyethane or inhalation of its vapour may cause unconsciousness.
11. Tetrachloromethane (carbon tetrachloride) is very toxic if swallowed or absorbed through the skin. It is also harmful to the eyes and lungs. It is a suspected carcinogen. When heated to decomposition, it yields highly toxic fumes of carbonyl chloride (phosgene).
12. Trichloromethane (chloroform) vapour is a strong anesthetic which may cause drowsiness, vomiting or unconsciousness. The liquid is poisonous if ingested.
13. Common toxic gases, such as ammonia, bromine, carbon monoxide, chlorine, hydrogen chloride, hydrogen sulphide, nitrogen dioxide, and sulphur trioxide, should never be directly smelled in the course of experiments. To smell the contents of a container (e.g. test tube), hold the container about 10 cm away from the nose and fan any odour from the hand towards the nose.

Storage of Toxic Chemicals

Toxic (poisonous) chemicals must be stored in proper containers (highly toxic chemicals should preferably be stored in double containment) and kept in a locked cupboard.

E. Harmful Chemicals

Harmful chemicals are those substances which if inhaled, ingested or penetrated through the skin, may involve limited health risk. Although the level of harmfulness seems to be lower than that of the toxic chemicals, same care as well as safety precautions for toxic chemicals should also be taken when handling harmful chemicals.

1. Millon's reagent causes dermatitis, and is harmful by skin absorption or ingestion.
2. Methanal (formaldehyde)—the liquid and its solution (formalin) are harmful if ingested.

3. Phenylamine (aniline) and its hydrochloride are harmful by skin absorption and ingestion. Their vapours are harmful if inhaled.
4. Naphthalene is harmful by inhalation, ingestion and skin absorption. In addition it is found that some 4.5 per cent of local born male babies suffer from G6PD (glucose-6-phosphate dehydrogenase) deficiency which is a hereditary disease and would last for life; people with such deficiency when exposed to naphthalene (e.g. in mothball) may suffer from haemolysis (destruction of blood cells). Hence, naphthalene should NOT be used in science experiments such as melting point determination and the study of cooling curves. Naphthalene should be replaced by wax or octadecan-1-ol in these experiments.

Storage of Harmful Chemicals

Harmful chemicals should be stored under lock and key.

F. Oxidising Chemicals

Oxidising chemicals are those chemicals which may give rise to highly exothermic reactions when in contact with other substances, particularly flammable substances.

1. Concentrated nitric acid will induce violent reaction when in contact with ethanoic acid, ethanol or propanone. It will also ignite when mixed with aluminium, lithium, magnesium, sodium or potassium. This acid should be stored at low level, preferably in a tray to contain spillages, and it should be kept away from metals and combustible materials including organic substances.
2. Potassium manganate(VII) (potassium permanganate) will form vigorously burning mixtures upon mixing with metal powders or combustible materials. This chemical should be kept away from other flammable chemicals in the laboratory.
3. Chlorates(V) (chlorates) and chlorates(VII) (perchlorates) are highly oxidising agents. Wood and clothes impregnated with solutions of these chemicals will ignite easily and burn very vigorously when dry. Chlorates(V) and chlorates(VII) may also decompose explosively on heating. These chemicals should be kept cool, uncontaminated and away from combustibles such as wood, cork, plastic, carbon, sulphur and powdered metals, etc.

Storage of Oxidising Chemicals

Oxidising chemicals should be stored cool and away from flammable substances.

G. Explosive Chemicals

Explosive chemicals are those chemicals which may start reactions spontaneously upon sudden change in temperature, pressure or mechanical

friction and vibration. The reactions are usually violent and explosion often results.

1. 2,4,6-Trinitrophenol (picric acid) is potentially explosive when subjected to heating, scratching or abrasion. This chemical should not be stored in the school laboratory.
2. Azides may result from prolonged standing of Tollen's reagent, and are liable to explode without any apparent provocation. The storage of Tollen's reagent is not recommended.

Storage of Explosive Chemicals

Explosive chemicals should be stored in a strong locked cupboard, away from heat and moisture and be regularly inspected. Containers of these chemicals should be marked with the date of receipt. It is always advisable to keep the minimum amount sufficient for current use.

H. Carcinogenic Substances

Carcinogens are chemicals causing or suspected of causing cancer. The following carcinogens should not be used in educational establishments:

asbestos
chloroethene (vinyl chloride)
4-aminobiphenyl
4-nitrobiphenyl
4,4-dinitrobiphenyl
1-naphthylamine
2-naphthylamine
benzidine
and the salts of the last 3 substances.

A large number of other substances, listed below, have been shown to cause cancerous growths in animals. It is possible that they could have similar effects in man.

1. Polycyclic aromatics and their derivatives.
2. Aromatic amines, nitro compounds and related compounds.
3. N-nitroso compounds of the general formula RN(NO)R' and the related N-nitrosamides RN(NO)COR'.
4. Complex mixtures such as coal tar, crude petroleum.
5. Benzene.
6. Trichloromethane (chloroform) and tetrachloromethane (carbon tetrachloride).
7. Other specific substances such as azoxyethane, 1,2-diethylhydrazine, urethane, thiourea, nitrogen mustard, cyclophosphamide, tetramine, β-propiolactone, etc.

The above list is by no means exhaustive. The compounds named serve to indicate the wide range of substances which may have carcinogenic activity.

BCME (Bis-chloromethyl ether) can be formed spontaneously from the vapours of methanal (formaldehyde) and concentrated hydrochloric acid under normal laboratory conditions. It is a powerful carcinogen at very low concentration if inhaled continuously. Every precaution should be taken to reduce the chances of the two vapours mixing in the laboratory.

In general, the effects of chemical carcinogens are long-term and insidious, rather than immediate and obvious. It must also be realized that these substances can enter the body not only by ingestion, but also by inhalation and skin absorption. The known cases of carcinoma in man attributable to the substances listed have normally been due to prolonged exposure in industrial conditions, either of manufacture or use. It is unlikely that students are at great risk while exposed to these compounds for the much shorter periods involved in educational experimentation. At the same time it should be made clear that no threshold dosage has yet been established nor has a safe maximum time of exposure. For as long as this information remains undetermined it is advisable to take careful precautions.

The use of asbestos in the laboratory should be avoided. In particular, the use of asbestos wool and powder, which will create airborne asbestos fibres, is strictly forbidden. Glass wool and mineral wool such as 'Rocksil' are possible alternatives. Wire gauzes with asbestos centres should be replaced by wire gauze with ceramic centres. Asbestos boards should be replaced by suitable substitutes e.g. bench mats made of glass reinforced cement. Schools are strongly advised to replace asbestos fire-blankets by fibre glass or other substitutes approved by the Fire Services Department. If schools wish to retain the asbestos specimen in the mineral specimen set used for the teaching of Integrated Science, they should ensure that the asbestos specimen be securely sealed inside a transparent plastic box.

It is recommended that each school should prepare a list of the names and quantities of known or suspected carcinogens held under its control. This list should be kept up-to-date and should be held in the custody of a senior staff.

Storage of Carcinogenic Substances

All carcinogenic substances should be stored in tightly sealed containers, preferably in double containment, labelled 'CARCINOGEN', and kept in a locked cupboard.

INCOMPATIBLE CHEMICALS

Some chemicals are 'incompatible' because they react together to pose corrosive, toxic, fire and explosive hazards. As far as is practicable, incompatible chemicals should be stored away from each other.

The following is a list of common chemicals and their major incompatible chemical(s):—

Chemical	*Incompatible chemical(s)*
Ammonia (.880)	Copper, aluminium, zinc, galvanized metals, silver, and alloys of these metals, halogens.
Ammonium nitrate	Combustible materials, strong acids, organic materials, chemically active metals, powdered metals, nitrates(III) (nitrites), chlorates, sulphur.
Bromine	Combustible materials, metals such as iron, copper and their alloys, alkalis.
Calcium carbide	Water, aqueous solutions of chemicals.
Calcium oxide	Water, strong acids.
Carbon, activated	Calcium chlorate(I) (calcium hypochlorite) and other oxidising agents.
Copper	Hydrogen peroxide.
Chlorates(V), Chlorates(VII) & Chloric(VII) acid	Acids, reducing agents, metal powders, sulphur, finely divided organic compounds or combustibles.
Ethanol (ethyl alcohol)	Kerosene, thinner.
Hydrogen peroxide	Combustible materials, metals such as copper, chromium, iron and their salts, nitric acid, potassium manganate(VII) (potassium permanganate), phenylamine (aniline).
Iodine	Ammonia, ammonium salts, acetaldehyde, combustible materials, aluminium, chemically active metals, powdered metals, carbides, ammonium hydroxide.
Methanal (formaldehyde) and formalin	Strong acids, strong bases, alkali metals, amines, ammonia, phenol. [When mixed with concentrated hydrochloric acid, BCME (bis-chloromethyl ether), a strong carcinogen, is formed.]

Chemical	*Incompatible chemicals(s)*
Nitrates	Sulphuric acid.
Nitric acid, concentrated	Metals and organic compounds. [When mixed, a fire may occur or toxic fumes of oxides of nitrogen may produce.]
Nitrates(III) (Nitrites)	Acids.
Phenylamine (aniline)	Hydrogen peroxide, strong bases, strong acids, zinc, aluminium, solutions containing iron salts.
Phosphorus	Caustic alkalis, reducing agents.
Phosphorus(V) chloride	Water, aqueous solutions of chemicals.
Potassium	Water, aqueous solutions of chemicals, acids and halogenated hydrocarbons.
Potassium manganate(VII) (potassium permanganate)	Ethane-1,2-diol, propane-1,2,3-triol, benz-aldehyde, sulphuric acid, hydrogen peroxide.
Propanone (acetone)	Trichloromethane (chloroform). [When mixed, an explosion may occur.]
Silver	Ethanedioic acid (oxalic acid), 2,3-dihydroxybutanedioic acid (tartaric acid), ammonium compounds.
Sodium	Water, aqueous solutions of chemicals, acids and halogenated hydrocarbons.
Sodium nitrate(III) (sodium nitrite)	Cyanides, strong acids, combustible materials, organic materials, ammonium nitrate and other ammonium salts.
Sulphides	Acids, zinc, copper, aluminium, and their alloys.
Sulphuric acid	Alkalis, chlorates(V), chlorates(VII) (per-chlorates), manganates(VII) (perman-ganates), ethanoic anhydride (acetic anhydride), combustible materials. [Concentrated acid reacts violently with water.]

CHEMISTRY EXPERIMENTS REQUIRING PARTICULAR CARE

From bitter experience, laboratory accidents always result from a combination of hazardous situations and human error. To minimize these, the science teacher must be prepared to take up certain professional responsibilities in addition to playing the normal roles of the teacher. The science teacher should pay undivided attention to students working in the laboratory, select alternative safer experiments when such are available, impart to students an awareness of laboratory safety and warn students not to conduct potentially hazardous experiments outside school laboratories.

Safety spectacles must be worn whenever there is any risk to the eyes. Risks may arise from explosions, powders, spills and splashes. Even tiny explosions, such as those caused by heating small quantities of potassium permanganate, often cause accidents to the eyes. Hence, whenever any operation with chemicals is performed, it is advisable to wear safety spectacles.

If a teacher intends to perform a potentially dangerous experiment in front of a class of students, a sheet of safety-glass or perspex acting as a safety screen, is recommended. The screen isolates the apparatus from the student observers. The teacher should also put on proper protective equipment, such as safety spectacles or a face shield, for his own protection.

In the subsequent sections, chemistry experiments requiring particular care are classified into three categories depending on the risk and seriousness of the hazard:

Category U— *U*nsuitable. The experiment is considered unsafe for use in schools.

Category D— *D*emonstration. These experiments involve a considerable element of danger and are recommended for teacher demonstration only.

Category C— *C*aution. These experiments can be performed by students with caution and only under close supervision of the teacher.

In addition, experiments marked (F) denotes that the use of the fume cupboard is recommended. However, teachers may have to use their discretion and allow some of these experiments to be carried out in a very well ventilated laboratory, using minimal quantities of materials.

The lists of experiments in the subsequent sections should not be taken as exhaustive. Under certain circumstances experiments not listed may still present some risk. However it is hoped that the lists will serve to illustrate experiments that are more widely known as dangerous.

Category U

These experiments are considered unsafe and schools are strongly advised *NOT* to conduct these in the laboratories. Students should also be warned *NOT* to carry out these same experiments by themselves outside the school.

U 1. Oxidation of ammonia, using oxygen in an enclosed apparatus.

U 2. Heating ammonium dichromate(VI) with aluminium or magnesium powder.

U 3. Electrolysis of molten cadmium iodide.

U 4. Preparation of carbonyl chloride.

U 5. Mixing chlorates with concentrated sulphuric acid or combustibles.

U 6. The reaction between halogens and ammonia.

U 7. The reaction of hydrogen and chlorine. (This refers to the gas syringe and similar experiments. Burning hydrogen at a jet in chlorine is acceptable as teacher demonstration.)

U 8. The reaction between chlorine and ethyne. (The reaction in which gases are generated simultaneously by adding dilute hydrochloric acid to a mixture of bleaching powder and calcium carbide is acceptable as a teacher demonstration, in which case a safety screen or the fume cupboard is recommended.)

U 9. Preparation of chlorine oxides.

U10. Preparation of cyanogen.

U11. Explosion of a mixture of ethene or ethyne with oxygen.

U12. Grinding or warming mixtures of chlorates, permanganates or nitrates with combustible substances such as carbon, sawdust, sulphur, and powdered metals such as magnesium and aluminium.

U13. Preparation of hydrogen cyanide by the action of acids on cyanides or cyanoferrates.

U14. Mixing nitrates with combustibles.

U15. Heating nitrates with sodium thiosulphate or tin(II) chloride.

U16. Preparation of N-nitrosamines from amines. (Note that these are carcinogens.)

U17. Action of chloric(VII) acid (perchloric acid) and chlorates(VII) (perchlorates) on combustibles.

U18. Mixing permanganates with concentrated sulphuric acid or combustibles.

U19. Preparation of rocket fuels.

Category D

The following experiments all involve a considerable element of danger and are recommended for teacher demonstration *only*. Teachers should be thoroughly familiar with the technique to be used. It is assumed that these experiments will have been rehearsed before being performed in front of a class for the first time.

D 1. Oxidation of ammonia by air or oxygen in an open vessel.

D 2. Heating ammonium dichromate(VI) ('Volcano' experiment). A fume cupboard is needed to avoid possible inhalation of chromate dust. (F)

D 3. Heating ammonium nitrate. Heating a mixture of ammonium chloride and sodium nitrate is considered safer. Use safety screens.

D 4. Preparation and heating of ammonium nitrate(III) (ammonium nitrite). This should be conducted in solution only at a concentration less than 1M.

D 5. Igniting ethene or ethyne in a gas jar.

D 6. Large scale generation and collection of hydrogen.

D 7. Burning hydrogen in air and in chlorine. Use safety screens.

D 8. Explosion of hydrogen with air and with oxygen. Use safety screens. Test tube scale only.

D 9. Reduction reactions using hydrogen. Use safety screens for the normal scale experiment.

D10. Preparation of hydrogen sulphide. (F)

D11. Heating lithium. Use safety screens.

D12. Heating mercury. (F). The fume cupboard is essential and the exhaust fan must be left on during the experiment and when the mercury is above room temperature.

D13. Heating mercury(II) oxide. (F). The fume cupboard is essential.

D14. Preparation of phosphine. (F)

D15. Burning white phosphorus. (F)

D16. Reaction of potassium with water. Use safety screens.

D17. Heating potassium chlorate and manganese(IV) oxide. Many safer alternatives for oxygen preparation are available. Use demonstration to illustrate catalysis only. Use safety screens.

D18. Electrolysis of sodium hydroxide (molten). (F)

D19. Preparation of oxygen from sodium peroxide. Use safety screens.

D20. The reaction between sulphur and zinc. Do not confine the mixture in any way, i.e. heat the mixture on a ceramic centred gauze or mineral fibre paper. Use safety screens.

D21. Thermite reaction of metal oxides with powdered aluminium. Use safety screens. Iron(III) oxide and chromium(III) oxide are safe oxides to use. Do not use copper(II) oxide, manganese(IV) oxide or chromium(VI) oxide.

D22. Combining nitrogen and hydrogen. Use gas syringes.

Category C

Some experiments, listed below, many present dangers to students. Teachers should be particularly vigilant when their students are performing these experiments. Small scale experiments are recommended, thereby minimizing the effect of any experimental accident that may occur.

C 1. Reactions of aryl and acyl halides. (F)

C 2. Reactions of calcium carbide with water.

C 3. Reduction of metal oxides with carbon monoxide (or town gas). (F)

C 4. Preparation of chlorine using potassium manganate(VII) (potassium permanganate) and concentrated hydrochloric acid. Cover the permanganate with water first. This experiment is highly dangerous if sulphuric acid is used by mistake instead of hydrochloric acid. It would be safer to use fresh bleaching powder or sodium chlorate(I) (sodium hypochlorite) and dilute hydrochloric acid or sulphuric acid.

C 5. Reaction of chlorine with metals. (F)

C 6. The addition of water or ethanol into concentrated acids, especially concentrated sulphuric acid, must be avoided.

C 7. Reactions involving hydrogen sulphide. (F)

C 8. Heating iodine in air. (F)

C 9. Organic nitrations. (F). In some cases when only a mild nitrating agent, such as dilute nitric acid, is necessary, a fume cupboard is not needed (e.g. nitration of phenols).

C10. Pipetting of solutions of ethanedioic acid (oxalic acid) and ethanedioates (oxalates). Pipette fillers should be used.

C11. Reactions of phosphorus halides with water. (F)

C12. Polymerization and depolymerization of acrylics. (F)

C13. Polymerization of phenylethene. (F). The fume cupboard is essential.

C14. Burning of polymers such as polyvinyl chloride (PVC), polystyrene, etc.

C15. Heating potassium manganate(VII) (potassium permanganate). Eye protection is essential.

C16. The reduction of silicon(IV) oxide with magnesium or aluminium. The reactants must be dry. Use safety screens.

C17. The reaction of sodium with water. Use safety screens.

C18. The reactions of concentrated nitric acid. Use a fume cupboard if corrosive or toxic gases are likely to be evolved.

C19. The reactions of concentrated nitric acid. Use a fume cupboard since nitrogen dioxide, which is toxic, is often evolved.

In certain reactions, gases liberated from a heated reaction vessel may be collected over water e.g. thermal cracking of medicinal paraffin. In such cases, there is the likelihood of sucking back when the heat source is removed before the delivery tube is disconnected from the reaction vessel. This may cause water sucking back into the hot reaction vessel resulting in cracking. As a preventive measure, the delivery tube should first be disconnected from the reaction vessel before the heat source is removed.

PROCUREMENT OF ACETYLATING SUBSTANCES BY SCHOOLS

Schools conducting advanced level chemistry courses may wish to acquire acetylating substances i.e. ethanoyl chloride (acetyl chloride) and ethanoic anhydride (acetic anhydride) for experimental purposes. A requirement under the Acetylating Substances (Control) Ordinance is that such schools must apply for a Dealer's Licence from the Commissioner of Customs and Excise. The application for Acetylating Substances Dealer's Licences should be made on Form CED 452 (in duplicate) obtainable from the Dutiable Commodities Office, Customs and Excise Department, at Second Floor, Harbour Building, 38 Pier Road, Central, Hong Kong.

An inspection to ascertain the suitability of the prospective licensed premises will be arranged.

Schools possessing acetylating substances should store them in a locked cupboard in the laboratory and keep an up-to-date record of usage of these substances.

DISPOSAL OF SPILLAGE AND CHEMICAL WASTES

A. Spillage Disposal

Spilled chemicals which are relatively harmless, such as sodium hydrogen carbonate or hydrated copper(II) sulphate, may be washed safely down the drain with a copious flow of water. However when dealing with spillages of hazardous chemicals, appropriate protective equipment should be put on. Some guidelines on such disposal are as follows:

Nature of spillage	*Disposal method*
1. Acids and acid halides	Cover with solid sodium carbonate. Mop up with water. Wash down the drain.
2. Organic liquids	
(*a*) Non-flammable	Emulsify with detergent. Mix with water. Mop up. Wash down the drain.
(*b*) Flammable	Absorb in sand. Shovel into a metal bucket and burn the liquids in a safe place.
3. Mercury	Cover up remnants of mercury with zinc dust (or a thin paste of sulphur and lime). Leave for a few hours, then sweep into receptacles.

B. Chemical Wastes Disposal

The Waste Disposal (Chemical Waste) (General) Regulation (hereafter, the Regulation) under the Waste Disposal Ordinance (Cap. 354) was enacted in May 1992 and has been fully implemented with effect from 3 May 1993. The Environmental Protection Department (EPD) has advised that according to the Regulation, all educational establishments (including secondary schools) with science laboratories and/or technical subjects workshops are required to register with EPD as chemical waste producers and to store up, prior to collection for disposal by licensed collectors, the following three main types of chemical wastes which arise as a result of practical work in science laboratories and technical subjects workshops:

(*a*) strong acids and alkalis with concentrations as defined in Schedule 1 to the Regulation;

(*b*) spent organic solvents; and

(*c*) surplus or expired chemicals.

With effect from 3 May 1993, secondary schools are required to comply with the Regulation with respect to the registration as chemical waste producers and the storage and disposal of these chemical wastes.

The general requirements for segregation, packaging, labelling, storage and collection of chemical wastes generated in schools are detailed in General Schools Miscellaneous Circular No. 51/93 which was issued on 26 May 1993 and is reproduced as Appendix 3 of this pamphlet.

To obviate disposal exercises for unwanted or deteriorated chemicals, stocks of chemicals, especially hazardous ones, should be kept to a minimum while ensuring adequate supplies for teaching purposes.

HANDLING AND STORAGE OF GLASSWARE

The following are some guidelines concerning the safe handling and storage of glassware in school laboratories:

1. Large glass bottles should not be lifted or carried by the neck, nor cradled in the arms. The main body of the bottle should be grasped firmly and trolleys or special Winchester carriers should be used.
2. Damaged glassware should be discarded and never used for experiments.
3. Pieces of broken glass must be discarded into a metal or plastic container and never into a general rubbish container. If glass is broken in a sink, the pieces should be removed from the sink with tongs.
4. Heat-resistant glassware should be used when liquids are to be heated.
5. When glass tubing and rods are being cut, the hands should be protected with a piece of cloth when 'snapping' the cut.
6. The sharp ends of glass tubing should always be polished in a flame.
7. Glass tubing when being inserted into a cork or rubber bung should not be pointed towards the palm of the hand. The size of the hole should be compatible with the size of the tubing, and a lubricant should be used—water for cork and vaseline for rubber.
8. It is always better to sacrifice a cork by cutting it than to struggle to remove stuck glass tubing.
9. Glass tubing should be stored, whenever possible vertically. If a horizontal rack is used, the tubing should not protrude beyond the end of the rack.
10. When a tight glass-stoppered bottle is opened, the bottle should be placed in a trough large enough to hold the contents in case of accidents and the stopper gently tapped. Brief gentle warming of the neck of the bottle can help.
11. The fitting of a pipette filler to a pipette should be done gently. During the process, the pipette should be held at the upper stem, and not the lower stem.

SAFE USE OF GAS

Gas is a clean and safe fuel when used properly. Schools should never attempt to carry out installation or repair work on fixed gas pipework or appliances. By law, such work must only be undertaken by registered gas installers (RGIs) employed by contractors registered with the government.

If liquefied petroleum gas is used in the laboratory, formal approval must be obtained from the Director of Fire Services and all fire services requirements formulated for such purpose must be observed at all times.

The Gas Authority strongly recommended on safety grounds that liquefied petroleum gas (LPG) cylinders should not be stored inside school science laboratories. For schools in locations where a piped gas supply is not available, LPG cylinders should be housed in an approved chamber external to school premises (i.e. within the entire school boundary but outside the school building) and the gas supply piped into the laboratories as required.

LPG cylinders must not be used in any locations below ground level where natural ventilation is not possible.

Gas taps with safety locks are recommended. Older type of gas taps without safety lock tend to loosen with constant use and should be checked from time to time and replaced when necessary.

Gas cocks incorporating safety shut-off facilities are recommended for use with Bunsen burners. Such facilities serve to stop the flow of gas automatically upon disconnection of the rubber tubing from the cocks.

The rubber tubings connecting gas taps to Bunsen burners should be of a type suitable for use with the gas being supplied and should be obtained from the gas supplier. Both ends of the tubings should be held in position by hose clips to prevent loosening. They should be regularly inspected for defects and replaced at least every three years.

All gas taps should be turned off after experiments have been completed.

The location of the main gas supply valve to each laboratory (with ON/OFF positions clearly marked) should be made known so that it can be turned off when the laboratory is to be unattended for an extended period of time or in an emergency. All downstream gas taps inside the laboratory must be in the OFF position before the main valve is turned on.

Make sure that ventilation in the room is adequate for the number of gas burners involved.

In laboratories where air conditioners are installed, all air conditioners should be switched off when doing experiments and exhaust fans switched on. All laboratory windows should also be left open.

If a gas leak is discovered or suspected, all gas supply taps should be turned off including the main valve to the laboratory. All windows/doors should be

opened wide and students evacuated from the laboratory area; electrical switches must not be operated; and all naked flames extinguished. The gas leak should be reported urgently in accordance with school procedures. The main gas supply valve must not be turned on again until the gas leak inside the laboratory has been located and repaired by an RGI. However, when gas continues to escape into the laboratory after the main supply has been turned off, or when a smell of gas persists, then Fire Services Department and the gas supply company must be contacted immediately in accordance with school emergency procedures.

As LPG is heavier than air, any leakage of LPG tends to accumulate at low level and will not dissipate easily unless there is plenty of ventilation direct to outside air at low level. In the case of Towngas, it is lighter than air and can be cleared by opening windows wide.

COMPRESSED GAS CYLINDERS

The Fire Services Department grants exemption from licensing if the following maximum quantity of cylinders stored in each school is not exceeded:

Type of Compressed Gas Cylinder	*Maximum quantity*
Oxygen	2
Nitrogen	1
Carbon dioxide	1
Hydrogen	1

Compressed gas cylinders should be handled with extreme care as a number of possible dangers are associated with the use and storage of compressed gas cylinders.

Compressed gas cylinders should never be stored near a fire risk, such as a store of flammable substances, nor in direct sunlight, nor near to any considerable source of heat. In use they should be fixed in stands, wall brackets, or trolleys in an upright position. When not in use they should not be kept in the laboratory, but should be removed to a well-ventilated store or preparation room; they should then be clamped in position or laid horizontally on the floor and wedged to prevent them from rolling. Dirt, oil or water should be prevented from entering cylinder valves. Compressed gas cylinders should be stored well clear of all corrosive substances.

Before use, the valve of every cylinder should be inspected. It is most important that the valve can be opened smoothly. Stiff valves should be treated cautiously. If possible, try to open the valve slowly by hand pressure using the standard key. (This should be strictly observed, especially for oxygen cylinders). Do not use hammers or excessive leverage. Do not lubricate any valve or fitting. Cylinders with stiff valves should be returned unused to the supplier.

Explosions have been caused by the too rapid opening of the valve resulting in compression heating in the regulator. Oxygen cylinders are liable to this type of accident. Oil or grease will ignite violently in the presence of oxygen, and if the latter is under pressure, an explosion may result. Do not handle oxygen cylinders, valves or any fittings with greasy hands, gloves or rags.

SAFETY PRECAUTIONS IN THE BIOLOGY LABORATORY

A. Precautions in Handling Chemicals

1. Methanal (formaldehyde) should not be stored with concentrated hydrochloric acid. Their vapours react under normal laboratory conditions to produce chloromethoxychloromethane bis(chloromethyl) ether, BCME which is a carcinogen. Since there is evidence that the same reaction takes place in the liquid state, they should be disposed of separately.
2. Phenylthiourea (phenylthiocarbamide, PTC) or PTC paper should not be used because of its high toxicity.
3. Flammable liquids, especially ethoxyethane (diethyl ether), propanone (acetone) and petroleum ether, should not be stored in domestic refrigerators. The thermostat control and door-switch of these refrigerators would generate sparks in operations. Vapours from flammable liquids stored in refrigerators would be ignited by the sparks, resulting in an explosion.
4. Animals which have been killed with ethoxyethane (diethyl ether) would pose the same hazard as ethoxyethane does if they are stored in domestic refrigerators. They should be exposed beforehand to the open air to have the ethoxyethane on their body completely evaporated away and their lungs should be removed if their storage in refrigerators is necessary. However, as ethoxyethane is highly flammable, the use of ethoxyethane to kill animals is not recommended.
5. Propanone (acetone) and trichloromethane (chloroform) should be disposed of separately. A mixture of these two liquids undergoes an exothermic reaction which may lead to an explosion.
6. To prevent poisoning, students should not perform any experiment in which mercury is used. If demonstration experiment is done by the teacher, a layer of water should be added to cover the surface of mercury so as to prevent the vaporization of mercury.

B. Precautions in Handling Equipment

1. *Dissecting instruments*

   Dissecting instruments should be sterilised before and after use. In free-hand sectioning of plant specimen, care should be taken in holding a razor to prevent cutting the fingers. Avoid using rusted dissecting instruments. Teachers should instruct their students to handle sharp dissecting instruments (e.g. razor blades, scissors, scalpels) with care and NOT to play with them.

2. *Syringes*

   (*a*) Used plastic syringes from hospitals must not be used in schools for experiments, because they cannot be re-sterilised and may carry pathogenic microorganisms, e.g. those causing blood-borne diseases, such as AIDS (acquired immune deficiency syndrome) and viral hepatitis B.

   (*b*) Accidents may arise if excessive pressure is exerted on the plunger of a syringe fitted with a needle. The needle may be blown off the syringe and the liquid content may spray into the eyes.

   Light pressure should be applied when using a syringe and the needle should be pointed away from the user and others in the laboratory.

   (*c*) Syringes and needles should be locked up in a cupboard and should not be easily accessible to students.

3. *Pipettes*

   Avoid using mouth suction with pipettes. It is advisable to use pipette fillers to transfer samples in pipettes.

C. Precautions in Handling Animals

1. Living animals may bite or scratch people handling them. They may harbour germs or parasites which can be transmitted to the human body. Their cages may house germs and become sources of diseases. Rubber gloves should therefore be worn when working with living animals and during cleaning of their cages or aquaria.
2. Animals must be kept in hygienic cages or aquaria of suitable sizes. (Teachers and laboratory staff should be aware of the Prevention of Cruelty to Animals Ordinance). The cages or aquaria should be cleaned with disinfectants regularly. Galvanised wire or polypropylene cages are recommended because they can be easily sterilised.
3. Laboratory animals must be obtained from licensed dealers. Vertebrates from the wild, dead or alive, should not be used. A list of local licensed animal traders selling lagomorphs and rodents has been published in the School Science Newsletter Issue No. 36. The list will be periodically updated and published in the School Science Newsletter.
4. Hypersensitive students may be allergic to fur or feathers. Teachers are advised not to allow taxidermic specimens of mammals and birds to be passed to such students in the laboratory.
5. Students should be warned not to touch the skins of taxidermic specimens. Arsenic compounds and mercury(II) chloride, which are poisonous, are commonly added to the fur or feathers of these specimens for preservative purpose.

6. Animal specimens which have been preserved in formalin may irritate the respiratory system, skin and eyes. A layer of barrier cream should be applied on the hands or protective gloves should be worn when handling such materials. These preserved specimens should be soaked in tap water for at least one hour before use for experiments.
7. Ethyl ethanoate (ethyl acetate) is recommended to replace cyanides in the killing bottle used for killing insects. However, it should be noted that ethyl ethanoate is highly flammable and its vapour may irritate the eyes and respiratory system.

D. Precautions in Dissection of Rats

1. Proper precautions should be taken in animal dissections (such as rats and rabbits). For details, schools are advised to refer to Appendix 2, the "Code of Practice for Rat Dissections in School Laboratories" recommended by the Hong Kong Examinations Authority. This code of practice is also applicable to rabbit dissections.
2. Students should not, under any circumstances, be allowed to handle living rats. Killing of rats should only be done by teachers or laboratory technicians, and in a swift and humane way.
3. If a student is bitten by a rat, the case should be reported to the teacher in charge at once. Basic first aid treatment should be given to the wounded student, who should then be sent immediately to hospital/ clinic for medical treatment. The animal in question should be isolated as it may be required for subsequent diagnosis.

E. Precautions in Handling Plant Materials

1. Students should be warned not to eat any plant materials used in experiment as many are poisonous themselves (e.g. castor oil seeds) or dressed with poisonous fungicide (e.g. maize grains and seeds purchased from agricultural suppliers).
2. Students sensitive to pollen should not be allowed to handle flowers.
3. Plants known to contain irritants should be kept inaccessible to students. *Alocasia odora* (alocasia), *Colocasia esculenta* (taro), *Euphorbia milii* (crown of thorns), *Euphorbia pulcherrima* (poinsettia), *Euphorbia tirucalli* (milk-bush), *Excoecaria agallocha* (milky mangrove), *Rhus chinensis* (sumac), *Rhus hypoleuca* (sumac) and *Rhus succedanea* (wax tree) are the most notorious examples.

F. Precautions in Handling Microorganisms

1. Cultures of microorganisms may be contaminated by pathogens which may arise from mutation or come from wild sources. All micro-organisms should therefore be treated as potentially hazardous and be handled with caution.

2. Pathogenic microorganisms may gain access into the human body if fingers with wound touch the culture or if the aerosols above the culture are inhaled or if contaminated food is ingested.
3. Students who are unable to appreciate the importance of safety precautions in microbiological experiments should never be allowed to perform them. If class discipline cannot be relied on, the teacher should abandon individual experiments in favour of teacher demonstration.
4. All hand-to-mouth operations should be strictly forbidden during microbiological experiments. Pipette fillers should be used to transfer liquid cultures. Teachers, technicians and students should wash hands thoroughly with soap and warm water after practical microbiological work. Paper towels are to be preferred to roller or other communal towels, which themselves may harbour large populations of microorganisms.
5. All cuts on body surface should be covered with waterproof dressings before starting microbiological experiments.
6. Avoid production of aerosols during sterilization of inoculating loop by flame heating. Always immerse the loop in 70% alcohol before flaming.
7. Never isolate microorganisms from potentially dangerous sources such as polluted water, human mucus, pus and faeces.
8. Do not incubate culture of microorganisms at 37°C because this practice tends to select microorganisms adapted to human body temperature. Most of the saprophytic microorganisms used in school microbiological experiment grow well at normal room temperature.
9. Cultures of microorganisms for class inspection should be kept in sealed containers to prevent contamination and infection. Self-adhesive tapes should be used to seal petri dishes containing microorganisms.
10. If the petri dishes containing cultures of microorganisms must be opened for inspection, the teacher or laboratory technician should kill the microorganisms by adding a few drops of methanal solution (formalin) to a piece of filter paper and leaving it in the lid for at least one hour prior to class inspection.
11. Unwanted cultures should be destroyed by autoclaving or immersing in disinfectant solutions (e.g. hypochlorite/'Chloros', or formalin) for several hours before disposal.
12. All apparatus contaminated with microorganisms should be autoclaved or immersed in disinfectant solutions for several hours before cleaning or disposal.
13. The bench surface and floor should be washed with disinfectant solutions immediately after each practical microbiology class. Areas contaminated with bacteria due to spillage or accidental breakage of the

container should be covered with disinfectant solutions and left for 15 minutes before cleaning.

G. Precautions in Physiological Experiments using Students as the Subjects

1. Some physiological experiments (such as the estimation of the vital capacity of the lungs and the investigation of the effects of exercise on the pulse rate), in which students may be used as the subjects, may exert excessive physical stress on some of the participating students. There must be no compulsion on the students to perform these experiments.
2. Students who are exempted from taking Physical Education lessons for medical reasons should not be allowed to take part in any physiological investigations involving strenuous exercise. Before conducting any experiments involving procedures which are outside the range of normal daily experience, teachers should ensure that students understand and comply with the appropriate precautions.
3. Taking human blood and cell samples in school laboratories carries a risk of transmitting blood-borne diseases such as AIDS (acquired immune deficiency syndrome) and viral hepatitis B. Experiments like mounting of human cheek cells, microscopic examination of human blood smear and investigation of the osmotic tolerance of human red blood cells are at such risk. Such practices should be discontinued in school laboratories.
4. For experiments that involve the use of body fluids, students should be asked to work only with their own body fluids.

SAFETY PRECAUTIONS IN BIOLOGICAL FIELD WORK

A. General

1. The school should inform the police and each participant's family about the route of the trip and the due time of return. Please refer to the Schools Miscellaneous Circular captioned 'Organised Visits by School Children: Safety Precautions', which is issued by Education Department at the beginning of each school year.
2. The teacher should pay attention to weather forecast in the evening before and in the morning of the scheduled date. A field trip must be cancelled whenever severe cold front or thunderstorm or typhoon is forecasted.
3. A map, a compass and a whistle should be carried when a trip is made in remote areas.
4. Clothing and footwear of each participant should be suitable for the work and the time of the year.
5. Suitable amount of food and drink should be carried individually by all participants when on a whole day trip, unless easily available elsewhere.
6. A field trip must not be extended to hours of darkness.
7. The group must carry a first aid kit, which should include adhesive plasters, sterile dressing/gauze, bandages, sunburn cream, antiseptics (e.g. Savlon, tincture of iodine), anti-histamine cream, cotton wool, and disposable plastic/vinyl gloves. It is much better to have someone with formal first aid training accompanying the group.
8. Plasticware should be used as far as possible. If glassware (test-tubes, beakers, bottles and petri dishes) is to be carried, it should be protected from accidental breakage. Care should be taken not to leave it on the ground, where it could become a hazard.
9. Keep to the established footpaths and avoid making new short-cuts. Snakes and venomous insects may hide among bushes and grass. Moreover, uncontrolled formation of new paths often starts soil erosion which is difficult to control.
10. Students who are not physically fit enough or exempted from Physical Education lessons must not participate in a field trip.

B. Terrestrial Habitats

1. To avoid cuts and wounds due to spines and thorns of plants, the participants should put on long-sleeved shirts and jeans. A hat with wide brim should be put on to avoid snake bite at the neck and head during a trip among trees.

2. Quite a number of plants in the wild are poisonous. Teachers should warn students not to ingest fruits, seeds or leaves of wild plants. Students should be warned not to touch those plants which are known to contain substances that induce allergic reaction or dermatitis on skin contact. *Nerium indicum* (oleander), *Rhus hypoleuca* (sumac), *Thevetia peruviana* (yellow oleander) and *Euphorbia milii* (crown of thorns) are the most notorious examples.
3. Students should be warned not to irritate wild animals, since quite a number of them are venomous themselves or are vectors of fatal diseases.
4. Keep to cleared foot-paths where possible.
5. Examine the surrounding area carefully before crawling under bushes to observe and collect specimens.
6. Examine rock or logs before sitting on them. Do not lift stones or other objects by hands, always use a stick to turn them over. Do not reach into holes.
7. Dead specimens of vertebrates in the field should not be collected or closely examined because of the risk of infectious diseases.
8. Plants and seeds collected from the field should be free from pests or diseases to limit the chance of infection on other plants.
9. On collecting animals and plants that bear spines or thorns, extreme care should be exercised to prevent injuring the body.
10. When collecting plants known to contain poisonous or irritating sap, avoid handling them with naked hands. Gloves should be worn.
11. When doing experiments of soil analysis, extreme care should be taken to prevent bites from organisms which may be hidden in the soil.

C. Shore Habitats

1. The teacher should always bear in mind the tide-time, and make sure to retreat before high tide.
2. Each participant should be properly dressed in shorts and plimsolls with adequate tread. Sandals and leather shoes should not be worn.
3. Never attempt rock climbing, caving, swimming and diving.
4. On rocky shores, the surface is uneven and often covered with slippery algae. It is sensible to try footing before putting weight down. Jumping from rock to rock may be dangerous.
5. On mangrove and sandy beaches, the surface may be slippery and the substratum unstable. It is safe to try footing before putting weight down.

D. Freshwater Habitats

1. Never work in streams after heavy rainfall, as flash flood may occur suddenly.
2. Except for very shallow ponds and ditches, work in freshwater habitats should be regarded as potentially dangerous, since current, submerged objects and slippery or muddy bottoms all pose hazards.
3. Each participant should be properly dressed in shorts and plimsolls with adequate tread. Rubber boots should not be worn.
4. Extreme care should be taken when placing the feet into streams. Always expect potholes and underwater obstacles.
5. Wading and swimming in pools and ponds should be discouraged unless where the depth of water and nature of substratum are known with certainty.

PRECAUTIONS IN THE USE OF ELECTRICAL EQUIPMENT

A. Installation

It is essential that electrical installations for laboratories should be done in such a manner as to comply with the safety requirements as stipulated in the Electricity Ordinance and its subsidiary Regulations, in particular the Electricity (Wiring) Regulations. All electrical accessories used (e.g. plugs, sockets and switches) should be obtained from reputable agents/suppliers. All electrical work should be carried out by electrical contractor(s) registered with the Electrical & Mechanical Services Department, except for those electrical installations which are installed or maintained by the Government.

A main switch which can isolate the supply to all outlets in the laboratory should be fitted. To prevent leakage of current to earth, every socket outlet should be protected by a residual current device having a rated residual operating current not exceeding 0.03 ampere.

Switched socket outlets, preferably with pilot lights, should be installed to facilitate local isolations. They should be placed away from any water tap such that they should not be splashed by water as far as reasonably practicable. Non-fused 13-ampere adaptor and plugs without cord grip should not be used.

B. Electric Shock

It should be stressed strongly that the passage of even small electric currents through the body may cause death by failure of the heart. It is the amount of current flowing through the body that determines the effect on the body. Any amount of current over 0.01 ampere or so is capable of producing a severe shock. Current exceeding 0.03 ampere is lethal.

Since the voltage at the outlets in the laboratory is usually fixed, such as 220 volts, the current that passes through the body is basically determined by the resistances of the human body. The actual resistance varies according to circumstances depending upon the points of contact, the moisture content of the skin and the voltage of the live parts. When wet, skin resistance can be reduced considerably. This greatly increases the chance for a severe electric shock.

The use of electricity in science laboratories is very common and the potential danger for electric shock is always present. It is important that basic safety measures be taken.

C. Safety Measures

1. Students must be made aware of the great danger resulting from bodily contact with a 'live' electrical outlet. They should not handle electrical appliances when their hands, feet or bodies are wet or when they are standing on a wet floor.

2. Switch off the appliance and/or the power supply before the plug is withdrawn/inserted.
3. Electrical equipment should be bonded effectively to earth through three-core supply cable and three-pin plug. Fuses should be of the correct rating for the equipment they are protecting. The connections between apparatus and three-pin plugs should be made with three-core flexible cable of adequate current rating. Braided flex should only be connected to portable equipment which has an outer covering of insulating material like plastic.
4. Danger from electricity can arise in the laboratory through ageing and resulting breakdown of the insulation. Apparatus in which heat is generated (e.g. hotplates, ovens, furnaces and motors) is particularly susceptible to damaged insulation. Frequent inspection of the state of the insulation should be carried out. Flexible leads should be replaced as soon as wear becomes noticeable; damaged leads should be wholly replaced, never patched.
5. Keep the use of extension cords to a minimum. Whenever leads are to be extended by plug and socket connection, the connection should be made by a well-matched set with the female socket being always the 'live' one and never the male plug, which has exposed pins.
6. The use of two or three-way adaptors should be avoided as this may overload the wiring and/or the socket.
7. Apparatus which gives the slightest shock should be repaired immediately. A piece of faulty apparatus should never be used until the fault is satisfactorily rectified.
8. In general, equipment should not be left switched on unattended for prolonged periods.
9. Flammable liquids should not be stored near electrical equipment because their vapours can be ignited by an arc or a spark. Charging of secondary cells such as lead-acid accumulators should be carried out in a well ventilated area.
10. Any experimentation requiring the use of high voltage would be safer if the floor is covered with effective insulating materials. Nobody should be allowed to work alone in a room when using high voltage. Terminals should be protected and naked wire should never be permitted. Suitable screen or barrier for protection against electric shock should be provided whenever necessary. All high voltage equipment should always be kept clean.
11. It is essential to ensure that there is a large current-limiting internal series resistor in E.H.T. power supplies so that even at 5 kV the short circuit current across the terminals is only about 2 mA or so.

D. First Aid for Electrical Injury

Please see page 54.

USE OF RADIOACTIVE MATERIALS

A. Sealed Source

The use of sealed radioactive sources for teaching purposes in schools is governed by the 'Code of Practice on the Use of Sealed Radioactive Sources for Teaching Purposes in Schools' which is reproduced below for ease of reference.

1. *General Rules*

   (*a*) The use of sealed radioactive sources in schools shall be solely for the performance of simple experiments to demonstrate fundamental principles, and the sources used and the methods of using such sources shall be such as to ensure that the degree of hazard is very small.

   (*b*) No demonstrations or experiments involving the deliberate exposure of students, staff or any other person to ionising radiation shall be performed.

   (*c*) Experiments should be carefully planned to minimize the exposure time, and preliminary rehearsals of the experiment procedure using simulated sources should be encouraged.

2. *Control of Sources*

   (*a*) The Radiation Board is the statutory body which controls the use and/or possession of radioactive material and irradiating apparatus in Hong Kong. Schools deciding to avail themselves of the opportunities to use sealed radioactive sources should apply to the Secretary, Radiation Board (c/o Department of Health), for exemption from requiring radioactive substances licence.

   (*b*) It shall be the responsibility of a graduate member of the science staff, who shall be designated the source custodian, to supervise the use of all radioactive sources within the school. Should the source custodian leave the school for any reason, a fresh application for exemption will have to be made in respect of the newly appointed source custodian.

   (*c*) The source custodian shall be responsible for the procurement, storage, issue and return of sources and the correct use of all sealed sources.

   (*d*) The source custodian shall arrange for routine checks, at intervals not exceeding 6 months, of the integrity of encapsulation of all sealed sources by **Wipe Test*** and the efficiency and condition of all monitoring instruments. All the results shall be entered into a logbook which shall be made available for inspection by Radiation Board on request.

* **Wipe Test**
The source is wiped with a swab or tissue paper or cotton bud, moistened with ethanol or water. The activity removed is measured. Acceptance limit: 185 Bq (0.005 μCi).

For more detailed information on the WIPE TEST, please refer to "Notes on 'Code of Practice on the Use of Sealed Radioactive Sources for Teaching Purposes in Schools' " obtainable from Physical Sciences Section, Advisory Inspectorate, Education Department.

   (*e*) All sealed sources failing the routine checks should be considered as defective and withdrawn from use.

   (*f*) The teacher in charge of a class shall account for all sealed sources before the period of instruction is concluded.

   (*g*) Sealed sources should be used by a student only when under the direct supervision of a teacher.

   (*h*) The immediate responsibility of radiation safety in any experiment involving ionising radiation shall rest with the teacher in charge.

3. *Storage and Labelling*

   (*a*) All sealed sources shall be kept in a locked metal container.

   (*b*) Access to this container shall be limited to authorised members of the school staff.

   (*c*) The metal container shall be permanently labelled (See Appendix 1) in such a manner to indicate that it contains radioactive substances.

   (*d*) Individual sources shall be stored in separate, appropriately labelled, containers or compartments within the locked metal container.

   (*e*) Each source shall be quickly identifiable by the user.

   (*f*) Sealed radioactive sources and their containers shall be permanently labelled with the type of radionuclide together with the activity at a specified date.

4. *Handling of Sources*

   Sealed radioactive sources shall be handled with care and unnecessary handling of sources should be avoided. The following rules shall apply:

   (*a*) Sources shall be transported between the laboratory and their place of storage in their containers.

   (*b*) Radioactive sources shall only be handled by tongs or forceps. Teachers should note that specially designed tongs for the safe handling of sources are available from commercial suppliers.

   (*c*) Sealed alpha-emitting radioactive sources shall be handled with extreme care because of the necessarily fragile nature of their construction.

(*d*) Sealed sources should whenever possible be kept at a distance greater than 30 cm from the user, and should be pointed away from the human body.

5. *Damage to, Loss of and Disposal of Sources*

   (*a*) Retention of defective, obsolete or unnecessary sources of radiation is undesirable and positive steps should be taken for the safe disposal of such sources. Such sources should either be returned to the supplier and the Radiation Board notified; or be disposed of in a manner approved by the Radiation Board.

   (*b*) In the event of damage to, or loss of any sources, the Senior Occupational Health Officer or the Senior Physicist i/c, Department of Health should be notified immediately.

6. *The Degree of the Hazard*

   When due consideration is given to the limitation on the type of source, the activity of radioactive substances to be used in schools, and the total time in any one year such sources will be used by any one teacher or student, the degree of hazard from exposure to ionizing radiation to both teachers and students is very small. However, it is essential that students appreciate the nature of the hazard and the degree of care considered necessary in the handling of radioactive substances.

B. Open Source

1. Exemption from the necessity of possessing a licence may be granted to a school on application to the Radiation Board in respect of the use of open sources. The instructions in the 'Notes for Guidance on Use of Radioactive Substances in Secondary schools' accompanying the exemption certificate should be complied with.
2. Should a school wish to use other open sources or radioactive materials not in the lists of standard Physics equipment for secondary schools, the Senior Physicist i/c of the Radiation Health Unit, Department of Health, should be contacted for assistance.
3. Open sources should not, in any way, be poured down into the ordinary sewage system. These sources must be disposed of in a manner approved by the Radiation Board.
4. Conditions for storage and labelling of open sources are the same as those for sealed sources.
5. Preparation and handling of open sources should be carried out with extreme care so as to avoid spillage.
6. Vessels used to contain liquid radioactive materials should be clearly labelled such that they will not be mixed up with other vessels.

C. Rules for Radioactive Work

The following rules are suggested for working with materials of low activity in a school laboratory:

1. Topcoats and personal belongings must not be taken into the laboratory.
2. Laboratory coats must be worn at all times and removed when leaving the laboratory.
3. Wear rubber gloves while manipulating active materials and dispose of the gloves after use.
4. Do not eat, drink, store food or apply cosmetics in the laboratory.
5. Do not pick up a radioactive source with the fingers. Tongs or tweezers must be used for manipulating sources.
6. Do not hold a radioactive source close to the eye for visual examination.
7. Do not use the mouth for pipettes, wash bottles, or any other laboratory operation.
8. Do not boil radioactive solutions or liquids.
9. Spills of active materials must be immediately cleaned up and the affected area monitored. All spills must be reported.
10. Deposit all radioactive waste in the receptacles provided. Sinks must *not* be used for active waste.
11. Do not use cracked or chipped apparatus.
12. All radioactive preparations must be clearly marked on approval labels showing the chemical compound, solvent, radioactive nuclide, activity and date.
13. When measurements have been completed, immediately return all sources to their storage containers.
14. Report immediately to the supervisors any personal injuries sustained in the laboratory.
15. Before leaving the laboratory wash your hands and monitor for possible contamination.

LASERS

Low power lasers for school and college work have been available for many years. Like any other laboratory instruments, lasers have to be used with proper precautions. There are two main hazards associated with the use of lasers. The greater risk is that of electrocution. Almost all lasers have the potential of causing severe and possibly fatal electric shock because of the presence of live and other high voltages in the instruments. The precautions in the use of electrical equipment, as outlined in this pamphlet, should be followed. In addition, care must be taken not to spill any liquid on the laser. The other main hazard is the adverse biological effect induced by the laser radiation. Both the skin and the eye may be affected but the latter is far more susceptible to permanant radiation damage. The effective beam diameter of the laser is usually very small, and because of the very low beam divergence, it is quite possible for a person exposed to laser radiation to receive the full power of the beam through the pupil of the eye. The incident beam will be focused by the cornea and the lens into an extremely small but highly intense spot on the retina. The heat generated could cause irreversible retinal damage in a very short time.

Laser radiation protection is a complicated subject. Both the school staff concerned and the students should remember that the safety rules given below are good laboratory practices for using low power lasers. Such rules are not adequate for lasers with high power ratings or generating invisible radiation (which are not recommended for use in a school laboratory environment).

A graduate member of the science staff should be responsible for the procurement, storage, issue and return of lasers and associated safety equipment. He should draw up a list of safety rules and operating procedures and ensure that these are observed. Any person using the laser should be trained in its use and should be familiar with the safety precautions.

Safety Rules

Consideration should be given to the following:

1. The laser should never be viewed directly. Any collimating instrument such as telescope or microscope should not be used.
2. The laser beam should never be looked along and any part of the skin should not be exposed to the direct beam.
3. The laser should not be fired unless it is correctly aimed at the designated target area. Do not align the laser beam with the power on. Always use optical alignment first.
4. Whenever possible non-reflective or absorbing materials should be used in the vicinity of the laser to prevent specular reflection. When such reflection cannot be avoided, for example at a lens surface, position some protective screens so that students and teachers are not exposed to the reflection.

5. The protective screens should be made of non-flammable material. They should be optically opaque and should be painted a matt grey colour.
6. Students should be positioned so that the protective screens are effective and they should never be closer to any part of a laser demonstration experiment than one metre when the power is on. They should stand behind the laser and at right angles to the proposed path of the beam before firing.
7. The laser beam path should be located well above or below the eye level of the students.
8. The laser source should be rigidly fixed so that the direction of the beam cannot be inadvertently altered.
9. Experiments with lasers should be carried out in brightly lit rooms to avoid enlarging the pupils of the eyes.
10. The danger of direct viewing and of specular reflections should be impressed on the students so that, in case of accidental exposure, they will react instantly by closing the eyes and/or turning the head away.
11. When a laser is in operation, warning signs (See Appendix 1) should be displayed in conspicuous locations both inside and outside the demonstration or experiment area and on doors giving access to the area.
12. Adequate protective spectacles should be provided for all staff who may enter or work in the laser area and are liable to be exposed to laser radiation.
13. The laser should be switched off immediately after an experiment.
14. The laser when not in use should be kept under lock and key so that it is accessible only to authorised members of the staff.
15. Any accidental exposure or even suspicion of exposure of the retina should be reported and medical treatment should be sought at once.

FIRE PRECAUTIONS

Every laboratory must be equipped with at least one appropriate fire-extinguisher, which should normally be installed near an exit and be easily accessible, i.e. not more than 900 mm above the floor. The following types of fire-extinguishers are suitable for laboratory use:

1. Carbon dioxide type
2. 'Dry powder' type

Fire-extinguishers should be inspected at least once in every twelve months. Expired or discharged fire-extinguishers must be promptly recharged by a registered fire service installations contractor.

In addition, there should be an approved type fire-blanket and two buckets of sand in every laboratory. All science teachers and laboratory staff should be familiar with the operation and handling of these appliances which must be kept in a state of instant readiness at all times.

Fire-blankets to be used for smothering clothing, which has caught fire, should be kept in the laboratory solely for fire-fighting purposes and be easily accessible.

Whenever a laboratory is not in use, its gas and electricity supplies should be switched off at the mains.

Schools should conduct fire drills regularly. All students, teachers and laboratory staff should be familiar with the escape routes from the laboratories.

All exit doors in the laboratories should never be locked during lessons. Furthermore, the passage for the laboratory exits should always be kept clear of obstacles. Gas supply and electricity should be turned off at the mains if practicable when it is necessary to evacuate the laboratory. It is essential that laboratory staff know the position of mains controls.

Poisonous, corrosive and flammable chemicals should be kept in a proper container clearly marked with the names of the chemicals and be stored in a locked room or cupboard except when the chemicals are being used in experiments. The key to the locked room or cupboard must be kept under control of the teacher-in-charge of the laboratory.

As advised by the Fire Services Department, schools are reminded to ensure that ethanol (ethyl alcohol) should not be stored together with kerosene and thinner in laboratory, workshop, art room or in any other room within the school premises, including the dangerous goods store.

General Guidelines in case of Fire or Explosion in the Science Laboratory

When there is a fire incident or an explosion occurring in a science laboratory, all available staff should be made use of to evacuate immediately the students

from the laboratory, or all the students from the school building if the situation becomes serious. It is essential that any such evacuation should be carried out in an orderly, controlled manner, and that every effort should be made to avoid panic amongst students. At the same time the Fire Services Department should be quickly notified by dialling 999. The Education Department should also be notified of the incident.

FIRST AID IN THE LABORATORY

Section (2) of Regulation 55 of the Education Regulations states that "at least two teachers in every school shall be trained in administering first aid". This is considered essential as teachers and school staff trained in first aid would be in a better position to provide care for those who become victims of accidents. In addition, school principals should encourage their science staff and students to undergo some form of training in first aid such as can be obtained from the St. John Ambulance Association & Brigade, Hong Kong Red Cross, Boy Scouts and Girl Guides.

In the event of any serious injury, or whenever in doubts, medical aid should be sought without delay. The most effective way of securing medical aid urgently is to make a 999 telephone call for an ambulance. All injuries to the eyes should be regarded as serious.

A. Fainting

A certain degree of faintness or dizziness may result from any accident, and the following measures should be taken:

1. The patient should lie down with feet slightly raised, and must be kept adequately warm—avoiding perspiration.
2. Verbal reassurance should be given to the patient.
3. Clothing should be loosened at the neck, chest and waist.
4. On recovery, sips of water may be given. (No attempt should be made to give liquids to an unconscious patient.)
5. If the injury has resulted in unconsciousness, the patient's pulse and breathing must be checked immediately. If these are present he should be placed in the recovery position i.e. on his back with his head tilted back to facilitate drainage of liquid from the mouth, and medical assistance must be summoned immediately. If breathing and pulsation have stopped, artificial respiration must be applied. (See page 57)

B. Electrical Injury

1. Switch off the supply affecting the patient, and remove him from contact with the apparatus. Never touch the patient with bare hands until you are sure that he is no longer in contact with the power source.
2. Check the body contact area for burn, which may be severe. Place a sterile dressing over the burn and secure with a bandage. Seek medical treatment.
3. It is essential that artificial respiration and cardiac massage must be started immediately if the shock has produced asphyxia and cardiac arrest. In this connection, it should be noted that recovery from electric shock is 90% certain if artificial respiration is started not later than one minute after the electric shock has been suffered. It is only 10% certain if there is a delay of as little as six minutes.

C. Heat Burns and Scalds

1. Reduce the intensity of the pain by cooling the affected area with lots of cold water.
2. Do not remove or detach clothing which is sticking to a burn.
3. Do not apply oil, grease or any chemical to the injured area.
4. Cover the area with dry, sterile dressings/gauze and then apply a bandage.
5. As far as possible, immobilize the affected part so as to minimize pain.
6. Obtain qualified medical attention without delay.

D. Chemical Burns

It is essential that only water should be used for first aid treatment of chemical burns.

1. Flood the affected area with slowly running water for at least 10 minutes to prevent further damage to the burned tissue.
2. Gently remove any contaminated clothing while continuously flooding the affected area. In doing so, care must be taken to avoid contact with the corrosive chemical.
3. For **severe burns**, medical aid should be sought without delay. It is essential that flooding of the affected area be continued all the while when an ambulance is being summoned for to send the patient for hospital treatment. A sample of the corrosive chemical should also be taken to the hospital for reference or identification.

E. Eye Accidents

Regard all injuries to the eye as serious, and seek medical treatment without delay.

However, immediate first aid may be given in some cases (e.g. from an eyewash bottle). Irritation due to vapour or spray may be treated by flushing with water for **several minutes**, with the patient lying down with head inclined to the injured side (if only one eye is affected). It is not advisable to attempt removal of foreign body except by irrigation with water.

Do not attempt to remove glass from the eye. Keep the patient still and send for medical aid immediately.

Do not attempt to neutralize chemical injuries to the eye by giving acid or alkali.

F. Cuts and Bleeding

1. Avoid touching the wounds with bare hands or having direct contact with blood; and always use a pair of disposable plastic or vinyl gloves.
2. Clean the wounds with water; using soap to clean away the dirt if necessary.
3. Apply antiseptic as necessary.
4. Apply proper dressing after bleeding has stopped.
5. **In serious cases**, the patient should lie down with the affected part raised. The ambulance should be called as a matter of urgency. Pressure should be applied to the wound with a thick pad of gauze which, if soaked through rapidly, should be covered with another pad without removing the first one. Pressure should be maintained on the pads by a firm bandage. Do not apply a tourniquet to a limb to stop bleeding.
6. **Blood-contaminated materials** should be properly handled and the following precautionary measures observed:
   (*a*) Avoid touching blood-contaminated materials with bare hands; always wear a pair of disposable plastic or vinyl gloves when cleaning up.
   (*b*) Use household bleach (diluted with water in the proportion of 1:3) to clean up the contaminated surfaces.
   (*c*) Blood-soiled gloves, dressing, cotton wool, cloth, etc. should be placed in double plastic bags and sealed for disposal. Advice from the Urban Services Department or Regional Services Department should be sought if dealing with huge amount of blood-soiled wastes.

G. Poisons (solids or liquids)

1. If in the mouth but not swallowed, spit it out and wash the mouth with plenty of water.
2. If swallowed, medical assistance should be summoned immediately. In the meantime the patient should be given plenty of water or milk to drink.
3. Emetics should not be given in either case. Milk may be given to the patient.
4. In the event that medical consultation has to be sought, a sample of the swallowed poison should be sent along to the hospital for identification.

H. Poisons (gases)

1. The patient should be carried into the fresh air.
2. A check should be made that the patient's air passages are not blocked.

3. Do not induce vomiting.
4. Place the patient in the recovery position even if he is not unconscious because he may vomit.
5. Seek medical aid immediately.

I. Artificial Respiration

Artificial respiration is the essential first aid treatment required by the victim of any accident which restricts the amount of oxygen available to the body or which causes breathing to stop. The treatment must be given without delay lest the central nervous system should suffer damage from which it cannot recover and the heart should cease to beat effectively.

The expired air method (mouth-to-mouth, or mouth-to-nose if the mouth is severely injured) is the most effective method, and is briefly described here. This description is not a substitute for proper instruction in the method, and as many teachers, laboratory technicians and senior students as possible should obtain instruction from a first aid organization.

To carry out the Expired Air Method of Artificial Respiration

1. Place the patient on his back.
2. Quickly inspect the mouth and nose to make sure they are free from obvious obstruction (e.g. false teeth).
3. Tilt the patient's head fully back to give a clear airway.
4. Breathe in, open your mouth wide and make an airtight seal over the mouth of the patient, seal the patient's nose by pinching his nostrils, and blow gently. (If your mouth is over the nose, see that the patient's lips are closed.)
5. During blowing, watch for chest expansion.
6. If the patient's chest does not rise, check that his mouth and throat are clear of any obstruction and that the head is titled backwards as far as possible.
7. Commence with two quick inflations of the patient's lungs, and then slow down to 12 respirations per minute, or blow again each time the patient's lungs have deflated.
8. With small children, inflation at the rate of about 20 per minute is achieved by a series of puffs, each one ceasing as the chest starts to rise. Blowing into the lungs should not be violent.
9. The patient's pulse must also be checked; if absent, commence cardiac massage simultaneously.

J. The First Aid Box

Each science laboratory should be equipped with a first aid box. Sections (3) and (4) of Regulation 55 of the Education Regulations require, respectively, that all science teachers and laboratory technicians should be familiar with the contents of the first aid box and their use and that all first aid boxes shall be maintained fully equipped at all times.

The first aid boxes should be installed in prominent and easily accessible positions in the science laboratories. Their contents should be regularly checked to ensure that all the recommended materials and equipment are kept in sufficient quantity and maintained in good conditions at all times.

The following is a list of first aid items recommended for school science laboratories:

Antiseptics, e.g. Savlon, tincture of iodine
Cotton wool
Disposable plastic/vinyl gloves
Sterile dressings/gauze
Adhesive plaster
Bandages (of different sizes)
Forceps
Safety pins
Scissors
Sterile adhesive dressings (of different sizes)
Sterile eye pad
Triangular bandages

ACCIDENT RECORDS AND INSURANCE

A. Accident Records

A careful record of all accidents in school laboratories should be kept by the teacher-in-charge. Each entry should contain: name of persons involved (teachers/laboratory staff/students), place, date, time of day, nature of accident, cause of accident (if known), purpose of experiment being performed, extent of injury and treatment given.

B. Insurance

It is essential that schools should ensure that adequate insurance be obtained to cover, among others, the following liabilities:

1. *Students' accidents both inside and outside the school*
   In addition to taking safety precautions in science lessons and in extra-curricular activities such as field trips, schools should take out an insurance policy covering accidental injury that may be sustained during such lessons and activities by students of the school.

2. *Employees' compensation*
   All science teachers, laboratory technicians and manual workers in school laboratories, irrespective of the level of their earnings, should be covered by insurance policies under the Employees' Compensation Ordinance.

3. *Fire*
   Science laboratories, furniture and equipment should also be insured against loss or damage by fire.

REFERENCES

Title	*Author/Source*	*Publisher*
The Care, Handling and Disposal of Dangerous Chemicals (Institute of Science Technology) (1970)	P. J. Gaston	Northern Publishers Ltd, Aberdeen
Chemistry of hazardous Materials (1977)	Engene Mayer	Prentice-Hall International Inc., London
Guide for Safety in the Chemical Laboratory, 2nd edition (1972)	Manufacturing Chemists Association	Van Nostrand Reinhold Co.
Handbook of Laboratory Waste Disposal (1986)	M. J. Pitt & E. Pitt	Ellis Horwood Ltd.
Hazardous Chemicals. A Manual for Schools and Colleges (1981)	Scottish Schools Science Equipment Research Centre	Oliver & Boyd
Hazards in the Chemical Laboratory (1981)	L. Bretherick	Royal Society of Chemistry
Manual of Hazardous Chemical Reactions, Number 491 M (1975)	National Fire Protection Association	
Material Safety Data Sheets (1993) (Disks)	City Polytechnic of Hong Kong	
Prudent Practices for Handling Hazardous Chemicals in Laboratories (1981)	National Research Council	National Academy Press, Washington, D.C.
Safeguards in the School Laboratory, 8th Edition (1981)	Association for Science Education	John Murray, London
A Safety Handbook for Science Teachers (1991)	K. Everett & E. W. Jenkins	John Murray, London
Safety in Science Laboratories, DES Safety Series No. 2 (1983)	Department of Education and Science	Her Majesty's Stationery Office, London
Safe Storage of Laboratory Chemicals (1984)	D. A. Pipitone	John Wiley & Sons

Title	*Author/Source*	*Publisher*
Science Teaching Project, Module 19, Safety in Science (1981)	T. Goodenough	Curriculum Development Centre, Canberra, Australia
Laboratory Animal Handbooks 5, Safety in the Animal House	J. Seamer (ed.)	Laboratory Animals Ltd.
Micro-organisms (A Schools Council Educational Use of Living Organisms Project) (1977)	P. Fry	The English Universities Press Ltd.
Precautions Against Biological Hazard (1974)	Imperial College of Science and Technology	University of London, London
Schools Council Educational Use of Living Organisms, Small Mammals	J. D. Wray	The English Universities Press Ltd.
The Use of Micro-organisms in Schools (1977)	Department of Education and Science	Her Majesty's Stationery Office, London
Use of Lasers in Schools and other Educational Establishments, (Administrative Memorandum No. 7/70)	Department of Education and Science	

APPENDIX 1

Safety Symbols

Safety symbols such as warning signs and hazard warning symbols serve to caution laboratory users as well as all those in the vicinity.

1. *Warning signs*—Standard warning signs have been established for a number of hazardous situations, such as radioactivity hazards and laser operations. Containers of radioactive sources should be permanently labelled in such a manner to indicate that it contains radioactive substances. When a laser is in operation, warning signs should be displayed in conspicuous locations both inside and outside the demonstration or experiment area and on doors giving access to the area. Some examples of warning signs are shown below:

DANGER
Laser beam

CAUTION
Radiation

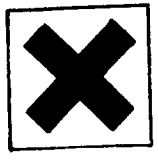
2. *Hazard warning symbols*—Containers of hazardous chemicals, such as reagent bottles, should bear appropriate hazard warning symbols which convey information on the hazardous nature of the substance. Examples of some common hazard warning symbols are shown below:

EXPLOSIVE

OXIDISING

CORROSIVE

FLAMMABLE



HARMFUL/IRRITANT

TOXIC

CARCINOGEN

APPENDIX 2

Code of Practice for Rat Dissections in School Laboratories

(*Note:* This code of practice recommended by the Hong Kong Examinations Authority only serves to present some guiding principles for schools to follow. Relevant modifications may be required to suit the local conditions of each school)

1. DO NOT use wild animals; obtain specially bred animals from licensed dealers. (cf. 'List of licensed rat traders in Hong Kong', Education Department School Science Newsletter Issue No. 36). Whenever possible, use animals of known health status from the animal units of the two universities.
2. Kill animals in a swift and humane way, e.g. with CO_2 or chloroform. Killing should be done out of the sight of students. (As chloroform is toxic, the killing chamber should be exposed after use either in a fume cupboard or in the open air).
3. After killing, check that the animals are dead, immerse them in dilute disinfectant, and then hand them over to students for dissection. Choose disinfectants which are easy and safe to use.
4. Do not allow students to perform dissections outside the school laboratory. Before starting the dissection, ensure that students have covered any open wounds on exposed parts of their bodies. Instruct students to wear laboratory gowns and surgical/disposable gloves for performing dissections, and advise them to wear face masks.
5. Do not use rusted dissection instruments. Soak all dissection instruments, boards and gloves after use in disinfectant.
6. Wash hands thoroughly with soap after performing dissection.
7. Dispose of the dissected animals quickly and properly. Place the animal carcasses in sealed plastic bags, label the bags, and dispose of them at a designated refuse collection point. If the carcasses cannot be rapidly disposed of, store them temporarily in the freezer.
8. If on opening up the animal's body it is suspected that the animal is diseased, stop the dissection and dispose of the animal in the proper way.
9. Where appropriate, refer to the following ordinances related to animals:
   (*a*) Prevention of Cruelty to Animals
   (Chapter 169 of the revised edition 1979)
   (*b*) Animals (Control of Experiments)
   (Chapter 340 of the revised edition 1964)

10. Do not rear animals in the school for use in dissections, and inform students not to do so at home. Do not allow students to handle live animals, nor allow them to take the animals home. If necessary, the school may hold the animals for a short period of time. In such circumstances, act as follows:

(*a*) Place animals in a suitable part of the laboratory, which is well ventilated and where wild rodents and insects cannot gain access.

(*b*) Use cages which are designed so that they are escape-proof, can be cleaned easily, and have adequate facilities for feeding and watering. It is important that animals are separated from their excreta. Clean the cages, drinking bottles and other equipment regularly and sterilise them.

(*c*) Provide the animals with sufficient food on a regular basis and ensure that fresh drinking water is always available.

(*d*) Use clean and dry sawdust, or absorbent paper (preferably shredded) for bedding; change the bedding materials daily and dispose of them in sealed plastic bags.

(*e*) Keep the laboratory in a generally clean and hygienic state.

(*f*) Wear protective clothing e.g. rubber gloves, laboratory gowns, when handling live animals. Limit the handling of animals to that necessary for experiments or hygiene. Handling of animals should be limited to trained personnel.

(*g*) Wash hands thoroughly with soap before and particularly after handling animals.

(*h*) Kill any sick animals and dispose of them properly; isolate other animals that have been in contact with the sick animals, and watch carefully for the development of signs of disease.

(*i*) Advise laboratory technicians to be immunized against tetanus.

(*j*) If a person is bitten by a rat, apply basic first aid immediately, and then send him to a government hospital/clinic for medical treatment. Isolate the animal as it may be required for subsequent diagnosis.

(*k*) Seek medical treatment promptly in case of accidental injury while handling rats, cages, soiled bedding, etc. or during dissection.

(*l*) Persons who are themselves ill should not contact laboratory animals, as some human infections can also be transmitted to animals.

INDEX