SCOTTISH SCHOOLS SCIENCE
EQUIPMENT RESEARCH CENTRE

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Introduction

Surplus Equipment - Ballot

With the new Bulletin distribution arrangements have come a few complaints that delays are occurring in the internal distribution systems of either Regions or schools. Some teachers fearful that they may miss 'goodies' in surplus ballots have requested advance warning of Bulletin issues which will contain a surplus equipment offer. We are happy to meet this request and give notice here that **Bulletin 132** due in the schools (we hope!) by late August early September will contain a list of equipment on offer. Over to you, readers, and good luck in any efforts doing battle with the 'mushroom' system of communication!

Disposal article

From one kind of 'surplus' to another, - the whole of the rest of this bulletin is given over to an article on ''Disposal of Waste Chemicals and Potentially Hazardous Materials'' which is reprinted by permission and with minor deletions and amendments, from 'Education in Science', April, 1982.

The article formed part of the 'Safety in Science' series prepared by the ASE-convened working group of which SSSERC staff are members. Allen Cochrane SSSERC Assistant Director (Chemistry) has been particularly closely involved in the preparatory work for this article, so that he is well placed to answer any queries which may arise from its application.

Eclipse - again

Following our note in Bulletin 130 on methods of observing the partial eclipse of the sun due on 20th July, we received a call from Professor Childs a one-time chairman of what was then our Development Committee. Professor Childs pointed out that it is not generally realised that a pair of ordinary binoculars, focussed at infinity, can be used the 'wrong way round' to project a small but detailed image of the sun onto a suitably positioned screen. For example he finds that a pair of 8 x 30 binoculars produce an image about 40mm in diameter at a screen distance of ca. 60cm. This is a trick worth knowing about even when an eclipse is not on offer as it will be this month, the image produced by this method being sufficiently sharp to allow one to observe sun spots. It should go without saying of course that one should **never** use binoculars for direct observation of the sun!

* * * * *

Disposal of Waste Chemicals and Potentially Hazardous Materials

1.0 Introduction

The disposal of hazardous materials, at least on a relatively small scale, is of necessity a common occurrence in school science laboratories. Each employer should provide guidance on (i) its policy on disposal of these materials and (ii) details of recommended methods and procedures for their disposal. **Teachers and technicians should follow such guidance irrespective of what is written here or elsewhere.** This article gives advice and guidance to teachers and technicians who may be handling the unwanted materials and be undertaking some DIY methods of disposal in a manner recommended by their employer. Advice has also been prepared for circulation to science advisers and employers and copies of this are available.

2.0 Types of Waste Materials Concerned

Examples of the types of dangerous or nuisance materials, many of which must neither be deposited with ordinary waste nor poured down the drain without either suitable pretreatment or in large amounts, include the following categories:

A. **Chemicals** which are
  (i) flammable,
  (ii) toxic or harmful,
  (iii) corrosive,
  (iv) likely to react unfavourably with other materials in waste,
  (v) strong oxidising agents and reducing agents,
  (vi) strong acids and alkalis,
  and certain persistent less easily degraded chemicals, e.g., haloalkanes.
B. **Radioactive materials**
C. **Hazardous biological materials**
D. **Pesticides**

3.0 General Principles

3.1 Responsibility to Others

The processes and methods used should be carried out in a way which is as safe as possible to all concerned. Responsibilities extend beyond teachers and technicials to pupils, cleaners, refuse collectors, sewage plant operators, to children and others who might be affected by materials placed in dust bins or tips, released into the atmosphere, or poured down sinks. The methods used should not contravene any existing legislation and should meet any special conditions or restrictions which may be laid down by the local Drainage Departments in whose area the school is situated. Flammable and toxic substances placed in drains may cause explosions or release toxic gases in sewers, or possibly poison the bacteria which play such a vital role in the break-down of sewage. Large quantities of gases released into the atmosphere may adversely affect the health of neighbours.

3.2 Choice of Method

The choice of whether to undertake DIY disposal or to employ a contractor will depend almost entirely both on the hazardous nature and on the quantity of the chemicals and materials involved. DIY methods have the advantage of being able to dispose of chemicals "on the spot" and thus not requiring the storage of hazardous substances, often of uncertain purity. These DIY procedures will contain some degree of risk similar to that involved in the handling of the same materials in other situations, but can often be safely carried out by competent persons who have adequate facilities, i.e. a satisfactory fume cupboard and the existence of a suitable outdoor site for evaporating off volatiles.

The feasibility of DIY methods will also depend on the amounts permitted to be added to the local sewage system. Such information relating to the permitted levels of discharge can be most efficiently obtained by the employer (i.e. Education Authority or, in the case of a private school, the Governing Body) approaching the local Director of Drainage and the Environmental Health Officer (address in 'Yellow Pages') and then using the information and advice received to prepare a policy on disposal. Otherwise every school would have to contact these offices separately.

On the other hand, it must be recognised that DIY methods will not be suitable for all materials and quantities and sometimes there is no option other than to employ a contractor. Disposal by an outside contractor means that a teacher or technician will not have to undertake a potentially dangerous process, and nearly all materials can be disposed of in this way. However, apart from the high cost of employing a contractor, there is the added disadvantage of having to store hazardous materials, probably for lengthy periods of time. Materials awaiting removal should be well labelled, stoutly secured, and kept in a place normally inaccessible to pupils and where they are unlikely to harm staff. Generally they should not be kept with ordinary chemicals stock in a store. The appropriate safety signs and hazard warnings should be used.[8-10]

Substances which may be subject to detonation or are otherwise thought to be unstable should be set apart from the other chemicals awaiting collection by the employer or his agent, e.g. nitrophenols, ammonium halogenates, azides, and alkyne derivatives of metals, organic silver compounds, organic peroxides. Much also depends on the age and condition of the samples.

The need for disposal of chemicals can be reduced to a minimum if care is taken at the stage when chemicals are ordered. However, in spite of good housekeeping, small quantities of certain chemicals may require to be disposed of because of their short shelf life and largish minimum pack size combined with small and infrequent use. It is also possible to design experiments and courses so that the minimum of harmful products are formed (choice and scale of preparation). In some cases the product of one experiment can be used elsewhere, e.g. an ester just prepared can be used as the material to be hydrolysed in the next experiment or lead (II) iodide precipitated in a class experiment on stoichiometry can be collected, washed and used for electrolysis. This also serves as a good example of conservation to pupils.

4.0 **Disposal of Chemicals**

4.1 **How much**

The quantities of chemical waste with which teachers are commonly confronted are:

(i) washings from glassware (up to 5cm^3),
(ii) contents of test-tubes, beakers and flasks (5-200cm^3),
and
(iii) contents of stock bottles (up to 2½ dm^3 (litre) and kilogramme quantities).

The first two categories will be everyday occurrences, but the last is a more unusual event. The small amounts involved in the washing of glassware should present no problem. Unless the levels of discharge permitted by the local Water Authority or River Board are high, materials in the last category may well require the services of a contractor. However, large quantities of some materials can be divided into smaller portions, whose subsequent treatment and release into the drainage system or the atmosphere over a period of time may be acceptable. The fate of intermediate quantities, i.e. >200cm^3, depends on local conditions as explained above.

As a general guideline up to 200g per day of a given substance may be disposed of by adequate treatment and dilution, but smaller amounts are appended against certain chemicals in this document. **Generally the small amount of chemicals encountered daily in a school, e.g. acids, alkalis, oxidising and reducing agents and compounds of low toxicity, can be safely disposed of down the drain if well diluted. These can only be guidelines and will have to be amended for use in several areas of the country.**

4.2 **Do it yourself disposal**

Details of recommended DIY methods for disposal of a range of chemicals likely to be found in schools are given in the appendix. For convenience the materials have where possible been grouped together in families or types, but it must be remembered that on ascending a homologous series there is a decrease in volatility, flammability and in water-solubility and that this will have a bearing on the mode of disposal. There will also be some instances where a particular chemical requires different treatment from that given to other members of the grouping and in some instances it may still be included in that grouping but with any special precautions listed by means of a key.

a. Evaporation (Ev) should be carried out on a metal tray in a safe place outside and supervised. Allowance must be made for wind strength and direction, but the site of the operation should be at least 5 metres from buildings, other sensitive installations or passers-by. It should of course be inaccessible to pupils. Portions being evaporated should not exceed 1 dm^3 (litre) at a time, but smaller quantities of the order of 100cm^3 may be safely evaporated in the fume cupboard.
b. Small quantities of many water immiscibles (50cm^3) may be emulsified (E) by working them with an equal volume of non-flammable detergent and then washing to waste after diluting with water.

Other useful points to be considered are:—

a. The site used for running substances to waste should ideally be chosen so that it is as far "downstream" (at the lowest point in the drains before they leave the school premises) as possible consistent with not having to transport the materials long distances. Care should also be taken to avoid having mutually incompatible chemicals in the same drain. A large amount of flushing is required to remove substances from the larger open traps. There should also be concern for the result of chemical attack on the school's drainage pipes.
b. Care should be taken to ensure that as far as is reasonably practicable mutually incompatible chemicals are not placed in waste bins. Thought should be given to the arrangements for emptying the contents of laboratory waste bins. At the end of the day cleaners may pour together the contents of many different waste bins and unwittingly initiate a violent reaction or fire.
Paper towels and filters are common in laboratories and so no strong oxidising agent should be added to waste bins.
c. Simple calculations will show that a large amount of water is needed to adequately dilute chemicals to concentrations considered acceptable by the local water authorities.
d. Many reactive substances can be either "neutralised", diluted, or reacted with water or other reagents prior to washing to waste. It should be

remembered that many such reactions are highly exothermic and that in many cases **additions of only small aliquots followed by efficient stirring is essential** to dissipate heat and avoid a violent reaction.

e. A useful device to dilute and/or neutralise solutions is shown in Fig. 1. It frees the technician from standing over the materials, pouring and stirring. The rate of dilution or mixing can also be carefully controlled.

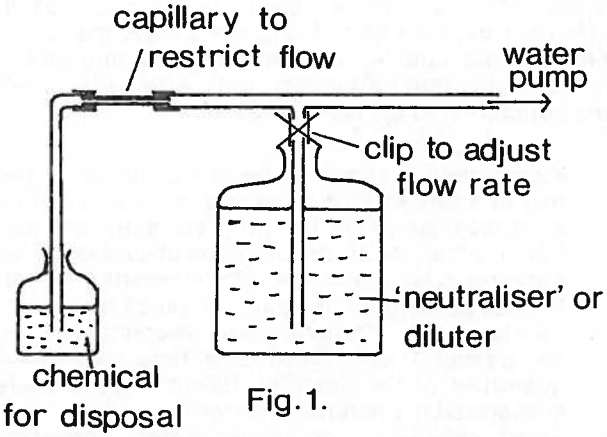

Fig.1.

Gases may be absorbed by the methods shown in Fig. 2 and Fig. 3 and if required fumes for burning materials like phosphorus can be collected as shown in Fig. 4.

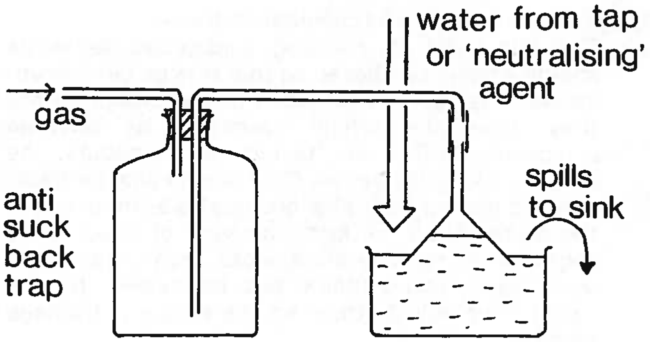

Fig.2.

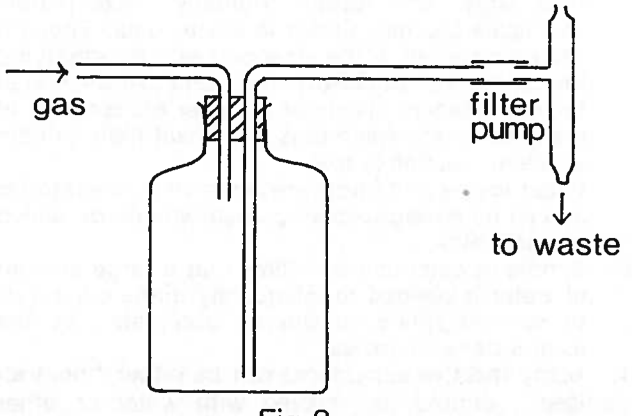

Fig.3.

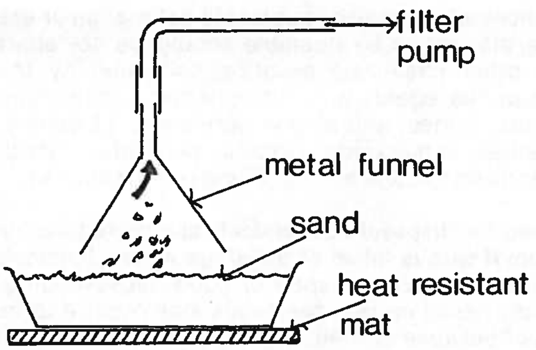

Fig.4.

Other useful items include a large plastic bucket and basin, a long stirrer and a liquid dispenser which fits into the neck of Winchester bottles.

f. Empty bottles should be carefully treated. Those which have contained corrosive liquids should first be emptied and then well rinsed. Those which have contained toxic liquids should be treated in a similar way to that used for small quantities of the chemical concerned. Solvent bottles should be cleaned out by adding water and detergent to displace any last remaining drops of volatile liquid. Care should be taken with those solvent bottles which have contained sodium as a drying agent, e.g. ethoxyethane (diethyl ether) and in these cases propan-2-ol should first be used to "destroy" any residue of sodium.

g. The teacher or technician undertaking disposal is advised to consult texts **and to be informed beforehand of the toxic, reactive and other hazards of the materials to be handled,** so that the appropriate precautions can be taken, i.e. use of face shields, gloves of suitable material, PVC apron, boots (open style shoes or sandals are most unsuitable), and to have present appropriate fire extinguishers, spillage kits, first aid kits and possibly respirators with suitable cartridges. Running water, from a short length of tubing on a tap, is advisable for an emergency eye wash. The particular items in a spillage kit which could prove useful would include:—

(i) mineral absorbent for soaking up spilt liquids,
(ii) sand for soaking up corrosives,
(iii) sodium carbonate for neutralising acid spillages,
(iv) citric acid for neutralising spills of alkalis.

A person should not undertake these tasks if alone, e.g. the technician by him or herself during school holidays.

h. Waste materials should not be stored for long periods. "LITTLE AND OFTEN" is a good motto for DIY disposal.

Disposal of noxious and hazardous chemicals by burial is not recommended and is a contravention of the Control of Pollution Act 1974.

j. Incineration of flammables has not been generally recommended in this article and should only be undertaken after advice from your employer.

In any case of doubt, a teacher or technician should consult their Science Adviser.

5.0 Radioactive Materials

5.1 Regulations

Most schools will probably be registered for Category C work as listed in the Schools Exemption Orders related to the Radioactive Substances Act 1960. This permits them to possess sealed sources of the approved type with no single source exceeding 370Bq (10μCi) and the total activity not exceeding 1.11MBq (30μCi). In addition, up to a total of 2 kg of compounds of uranium and thorium (naturally occurring in isotopic mixture) may be held.

Those using the radioactive tablet scheme for tracer experiments will need to be registered for Category B work. They may possess not more than a total of 4 millicuries (included exempted sources) and the total stock of open sources is not to exceed (i) 2 millicuries or (ii) five times the maximum permissible quantity per experiment (MPQE) (as listed in SED Circular 689) or whichever is the less.

5.2 Sealed sources

Sealed sources should be returned to the manufacturer. NRPB[16] often accepts such materials and will probably also collect such sources, but will make a charge. Such materials should not be sent by post; some delivery services, e.g. Securicor, will handle sources, but their charges are high.

The appropriate Government Departments should be notified of the intended disposal, e.g. The Scottish Development Department, as well as the SED.

5.3 Open sources

Open sources are generally in the form of those available under the tablet scheme with most tablets being 370kBq (10μCi) or less. When finished with, such sources should be disposed of as soon as possible. Those with very short half lives (^{131}I 8 days, ^{32}P 14.3 days) may be kept in a secure place for four or five half lives before dissolving in dilute acid and running to waste.

5.4 Liquid waste

Up to 18.5 MBq (500μCi) per week is permitted to be disposed of into foul water drainage. This upper limit is much more than ample to cover disposal of materials from school experiments. (It is also equivalent to approximately 1500g and 4500g of uranium and thorium compounds respectively. Apart from their radioactivity, salts of these two metals are highly toxic and it is recommended that the quantities run into drains are much smaller than this. In fact, it is unlikely for schools to possess as much as a fifth of these amounts.) If such experiments are carried out frequently a special sink or trap should be set aside or the lowest point on the sewage outfall used. All glassware, spillage trays etc. should be well washed with a suitable detergent such as Decon 90. Addition of a little EDTA or 2-hydroxypropane-1, 2, 3-tricarboxylic acid (citric acid) to the detergent facilitates the removal of surface absorbed radioactive materials. Addition of a "carrier ion" if not already present, assists in keeping the active material in solution.

5.5 Solid Waste

Up to 370kBq (10μCi) per week may be disposed of through the local authority disposal service. The waste should be in a container holding not less than 3ft^3 of refuse and no one article in the waste should have an activity of more than 37kBq (1μCi). It would be preferable to dissolve solids where possible, and dispose of them via the drain. Solids left will include swabs, paper wipes, syringes, filter papers, disposable protective covers for benches, tray liners gloves and miscellaneous materials such as plants, their pots and soil. Double containment should be used for any "sharps". (It is wise to use materials which may easily be disposed of, e.g. waxed paper or polystyrene cups as disposable plant pots.) A disposable fine dust respirator should be used for handling fine powders, e.g. thorium carbonate.

5.6 Gaseous waste

Up to 37kBq (1μCi) may be discharged per day into the air, but absorption of the gas into solution is to be preferred. $^{14}CO_2$ produced inside a large polythene bag for photosynthesis experiments can be absorbed into a strong solution of sodium hydroxide which is then disposed of via the drains. **Great care must be taken to avoid ingesting any radioactive materials.** Use of dust mask and fume cupboard is recommended for many processes, e.g. uranium and thorium salt handling during disposal.

6.0 Materials from Biological Sources

6.1 Introduction

Ideally much of the materials should be incinerated, but if this is not possible they should either be autoclaved or sterilised prior to disposal. Great care should be taken to avoid raising dust or creating aerosols.

6.2 Microbiology

Used Petri dishes and cultures should ideally be autoclaved in autoclavable disposable bags or soaked in 10% chlorate (I) (hypochlorite) solution prior to incineration. For full details, see the article on "Microbiology in Schools" in **Education in Science,** April 1981 or SSSERC Bulletin 126.

6.3 Liquid cultures

The lid of the bottle should be loosened slightly and the bottle and contents autoclaved before being carefully poured into a suitable drain (i.e. not a trapped laboratory sink).

6.4 **Syringes, needles and scalpel blades**

The syringes and needles should be mutilated in order to prevent their possible re-use. Autoclaving will render plastic syringes and needle luer fittings unusable as will incineration. It is also recommended that 'sharps' be placed in some suitably labelled secure container before disposal. Special 'sharps' boxes are available commercially but other containers (e.g. an empty syrup tin) securely closed and suitably labelled can be used.

6.5 Soiled cage litter

Soiled cage litter and faecal material should be sealed into an opaque plastic bag and then disposed of by incineration. A second choice and would be deep burial in a suitable place.

6.6 **Carcasses and remains**

Carcasses of animals which have died or been put down because of an infection should be placed in a thick plastic bag and incinerated. Healthy or preserved carcasses and "offal" used for dissection placed in a thick opaque plastic bag would be acceptable for ordinary waste.

7.0 **Pesticides**

Pesticides made available to the public under the Pesticides Safety Precautions Scheme (PSPS) will be in quantities not likely to pose a difficult problem in disposal.

Where quantities are small, great dilution will ensure that liquid pesticides run into sewers are unlikely to affect useful bacteria at the sewage works. If quantities are large, the Local Authority should be informed.

Solid pesticides should be left in the container with the lid firmly closed and placed in the dustbin.

For more details of the use of pesticides see the article on "The Use of Pesticides in Schools" in **Education in Science** November 1979.

APPENDIX

RECOMMENDED DIY METHODS FOR DISPOSAL OF CHEMICALS

Summary of **KEY**

Ev	evaporate
E	emulsify and wash to waste
W	dilute and wash to waste
( )	figures in brackets give a guideline to maximum quantity, but such amounts may be changed by your employer to take account of locally permitted discharge levels.

1. FLAMMABLES

Ensure all sources of ignition are removed (check that motor on fume cupboard fan is sparkproof), good ventilation is provided and appropriate precautions taken.

a. **Water reactive**

ethanol chloride (HCl evolved) ethanoic anhydride dichlorodimethylsilane (HCl evolved)	add slowly in small portions (1-2cm^3) with **stirring to large** volume of water (2 litres). After 12 hours neutralise and run to waste.

b. **Water soluble**—dilute well and wash to waste.

(i) **aliphatic alcohols**

methanol	W
ethanol	W
higher liquid alcohols	E, or Ev
higher solid alcohols	place in sealed packet in waste bin.

(ii) **aliphatic amines**—dilute fourfold with water, carefully neutralise with hydrochloric acid and wash to waste.

hexane-1, 6-diamine higher amines cyclohexylamine pyridine	E or Ev

(iii) **esters**

e.g. methyl ethanoate ethyl ethanoate	E or Ev
higher members if solid	small quantities E mix with sand, place in stout bags, seal and place in refuse.

(iv) **carbonyl compounds**

methanal ethanal propanone	W
higher members	E, or Ev
ethanal trimer (meta) hexamine	burn in fume cupboard or open place

c. **Water insoluble**

(i) **hydrocarbons** alkanes alkenes alkynes pet. spirit arenes	washings from glassware E; larger amounts Ev; if solid, mix with sand, seal into bags and place in refuse.
(ii) **halogenated hydrocarbons** (chloromethyl) benzene chloro and bromobenzene chloro and bromobutanes 1,2-dichloroethane chloroethane	small quantities such as washings E otherwise **DO NOT ADD TO DRAIN.** Ev, or collect for eventual disposal by contractor.

(many other members are less flammable, especially if polyhalogenated)

(iii) **ethers and derivatives**

ethoxyethane (diethyl ether)* ethoxyethanol† epoxypropane 1-chloro-2,3-epoxypropane tetrahydrofuran*† dioxan†	very small quantities (0-10cm^3)E large quantities Ev

*If bottles are old, take care, as explosive peroxides may have formed. There have been violent explosions on merely unscrewing the cap of a bottle containing di-isopropyl ether. If sample is old, consult other authorities for advice. Some samples of ethers contain sodium wire as a drying agent, and after pouring out the ether, the sodium should first be destroyed by dissolving in propan-2-ol or 2-methyl-propan-2-ol before washing out the bottle.
†These are fairly soluble in water.

d. Miscellaneous

carbon disulphide	Ev No sources of ignition or hot surfaces (even light bulbs) present.

2. FLAMMABLES, SOLID OR SOLIDS PRODUCING A FLAMMABLE GAS

a. Alkali metals and hydrides (30g)

On reaction with water these give off a flammable gas and leave a corrosive alkaline solution.

sodium (H_2) potassium* (H_2) strontium (H_2) barium (H_2)	In well ventilated area dissolve small pieces (pea size) in a large volume of dry propan-2-ol (2-methyl-propan-2-ol for potassium and barium) at the rate of 2g of solid per 100cm³. Allow reaction to finish, dilute and neutralise before running to waste. Rinse original container.
lithium (H_2) calcium (H_2) calcium dicarbide (C_2H_2 + traces PH_3)† aluminium carbide (CH_4) calcium phosphide (PH_3)† lithium borohydride (H_2)	Carefully add small pieces to large volume of water, allow time for reaction to be completed and neutralise before running to waste.
lithium hydride (H_2) sodium hydride (H_2) lithium aluminium hydride (H_2)	As above, but reaction is more violent. Alternatively, spread out in a damp atmosphere and help reaction to occur by breaking up crust. Transfer sticky residue to large volume of water, allow time for reaction, neutralise and wash to waste.
amalgam, sodium (H_2)	Add small amount to large amount of water. When reaction is complete, recover and wash mercury. The sodium hydroxide can be washed to waste.

b. Finely divided metal powders (20g)

In a fume cupboard add small quantities to dilute hydrochloric acid.

aluminium zinc magnesium iron nickel chromium copper	(nitric acid for nickel and lead and copper), dilute and wash to waste. Alternatively, disperse in sand, seal into polythene bags and place in waste bin.
lead (10g)	As above if quantities very small. Large amounts of lead and zinc may be melted (fume cupboard and hot-plate) and recovered as a block.

c. Phosphorus (red and white)

Carry out of doors and pour contents of bottle onto sand tray and allow to dry out. The white allotrope ignites spontaneously, but the red variety needs to be ignited. Alternatively, if burnt in a fume cupboard, the fumes may be scrubbed as shown in Fig. 4.

3. NON-FLAMMABLES

a. Halogenated hydrocarbons

Many of these have extremely toxic vapour and are readily absorbed by skin.

tetrachloromethane trichloro and tribromomethane (bromomethyl) benzene bromoethane dichlorobenzenes bromomethane	Except for smallest amounts, such as washings of glassware, **do not put into drain**, even after emulsifying. Ev or collect for disposal by contractor.

b. Water soluble inorganic salts

halides nitrates sulphates ethanoates	of	alkali metals & alkaline salts iron aluminium zinc magnesium copper nickel chromium manganese tin lithium (in small quantities).	Usually fairly large amounts may be washed to waste if well diluted.

oxides carbonates hydroxides sulphides (H_2S evolved)	Where insoluble may be treated with dilute acids to render them soluble.
nitrates	Only in small amounts.

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*If potassium is old and has a yellow crust, do not cut up or use above methods, but contact education authority to arrange for disposal by contractor.

† Phosphine gas is very toxic and good ventilation is needed even for small quantities. The gas often ignites spontaneously.

. **Water reactive producing alkali** and in some cases evolving gases.

sodamide* (NH_3) potassamide* (NH_3) sodium ethoxide calcium oxide calcium cyanamide (NH_3) sulphides of sodium and potassium (H_2S) sodium peroxide† hydroxylamine and salts	Add small quantities at a time to a **large** volume of water, await completion of reaction, neutralise with 2M hydrochloric acid and wash to waste.

Reaction can be violent and a safety screen should be used. Old samples (yellow) can give a delayed explosion.

Reaction can be violent.

I. **Oxidising agents**

chlorates bromates iodates	of oxidation states 1, 3, 5 and 7	Dissolve in water and, if quantities are greater than 50g, react with reducing agent, e.g. acidified Fe (II) salts and wash to waste. Wash any area of spillage well.
iodine pentoxide peroxodisulphate (VI) manganates (VII) hydrogen peroxide* dichromates (VI)		
bromine iodine		Add to strong alkali solution, neutralise and run to waste.
azides		Do not run even very dilute solutions into drains, as explosive heavy metal azides may be formed in the drains. Reduce first with hydrogen sulphide.
hydrazine hydrate and salts		Dissolve in water, acidify with dilute hydrochloric acid and oxidise with Fe (III) salts.
amalgam, zinc		Oxidise with an excess of acidified iron (III) solution, wash mercury and retain for purification or for a future preparation of amalgam.
organic peroxides*		See section on miscellaneous chemicals.

*Avoid contact with flammables, especially propanone.

. **Reducing agents**

thiosulphate sulphite iron (II) salts	Dissolve in water and, if quantities are greater than 50g, react with oxidising agent, e.g. sodium chlorate (I) solution, before running to waste.

. **Very toxic substances** (10g)

Carcinogens as listed in SED Circular 825 (1972) should not be used in schools, and if found should be disposed of by a contractor. 1, 2-dibromoethane should now be regarded as a potent carcinogen. Also see article in **Education in Science**, September 1979 or SSSERC Bulletin 117.

compounds of— arsenic[a] beryllium lead mercury[b] (also Millon's Reagent, Nessler's Reagent) thallium barium (sulphate excluded) cyanides[c] nitrites ethanediotes (oxalates)[d] diethyl and dimethyl sulphate[e] phenols nitrophenols benzene-1, 2-diol (catechol) benzene-1, 3-diol (resorcinol) benzene-1, 2, 3-triol (pyrogallol) 1, 2-dibromoethane bis (4-isocyanatophenyl) methane (MDI)[f] alkyl and aryl isocyanides methyl cyanides organo compounds of lead, mercury and tin phenylamine and derivatives quinoline, benzenediamines phenylhydrazines dimethylformamide	It may be permissible to run small amounts down the drain, but the local authority should be consulted first. Many heavy metals will be converted into insoluble sulphides by sewage but, if necessary, they can be precipitated from solution as either hydroxides or carbonates by addition of sodium carbonate or calcium hydroxide solution. On settling, the resulting liquor can be run off and the sludge collected for placing with refuse or for disposal by contractor.

a Avoid storing arsenic compounds in any container which may be reducing, e.g. a galvanised bucket has been shown to reduce arsenic compounds to the toxic arsine gas.

b The mercury should be recovered from salts by neutralising, reacidifying and reduction with warm phosphinic acid (sodium phosphinate + dilute hydrochloric acid).

c Very small quantities (i.e. 1-2g) may be destroyed by addition of excess sodium chlorate (I), allowing 24 hours for completion of reaction before washing the relatively harmless cyanate to waste. This should be undertaken only by an experienced person using a fume cupboard or outside facilities and after consulting the Science Adviser.

d Either warm and react with an excess of potassium manganate (VII) solution or add a solution of calcium chloride to precipitate calcium ethanedioate (oxalate) which may be washed away.

e One recommended method is to add small portions of '880 ammonia', stir and allow time for reaction to be completed before washing to waste. There have been reports of explosions during this operation, and it should only be undertaken with the greatest of care.

Small amounts of MDI can be treated with 5% sodium carbonate solution, allowed to stand for 24 hours before washing to waste. Alternatively, use propan-2-ol (50 vols.), and water (45 vols.).

g If quantities of amines and other organic bases are small, they can first be converted to soluble salts by leaving in a plastic bucket with hydrochloric acid for 24 hours prior to washing to waste.

g. Water reactive producing acidic solutions

tin (IV) chloride aluminium chloride, anhydrous titanium (IV) chloride phosphorus pentahalides* phosphorus trihalides phosphorus pentoxide sulphur dichloride oxide sulphur trioxide sulphuric acid oleum hydrogen sulphates hydrogen halide acids iodine chloride iodine trichloride	These react fast and and in some cases violently. Add in small portions to a **large** volume of water with **stirring**. In most cases hydrogen halide fumes will be evolved, and therefore the operation should be done in a fume cupboard, or outside in suitable weather conditions.
benzenecarbonyl chloride benzenesulphonyl chloride benzenesulphonic acid sulphur dioxide dichloride silicon tetrachloride zinc chloride phosphorus oxyhalides* phosphoric (V) acid	Treat as above, but reaction is slower and more time may be needed between additions to allow completion of reaction.
4-aminobenzenesulphonic acid aliphatic carboxylic acids aromatic carboxylic acids	Higher members may need to be made into sodium salt to render them soluble.

The residue left (presumably phosphorus oxychloride) in the original bottle after pouring out the bulk of the phosphorus penta-chloride has on occasions given rise to violent exotherms if left to soak in water. This can be prevented by using a continuous flow of water from a piece of rubber tubing in order to both dissipate the heat evolved and to promote mixing of the two phases.

4. MISCELLANEOUS CHEMICALS

a. Polyester resin

In ventilated area pour into shallow layers in trays to aid heat dissipation and add catalyst. Cured resin may be broken up and placed in refuse.

b. Gases

(i) **Sulphur dioxide syphon**
Release in open or through fume cupboard. Alternatively absorb fumes as shown in Figs. 2 and 3. Cooling the syphon helps to slow down the initial rate of evolution of gas.

(ii) **Hydrogen, oxygen and nitrogen**
These may be released into the atmosphere. Leave a small amount of gas in the cylinder to prevent air entering the cylinder.

c. Grignard reagent left in excess at end of reaction

Add slowly to a large volume of water. An alkane gas will be evolved and the damp ethereal solution of basic magnesium halide can be allowed to evaporate outside, any residue being washed to waste.

d. Photographic developer

Dilute and wash to waste.

e. Photographic fixer

Add dilute hydrochloric acid to ensure that all the silver has been precipitated. Allow the precipitate to settle out, decant, filter and wash out precipitate thoroughly. Finally, dry the precipitate, mix with sodium carbonate and heat strongly in a crucible. A small lump of solid silver will be obtained. This can, of course, be used t prepare a further supply of silver nitrate. (SSSERC Bulletin No 73, August, 1974). Another method is given in **The School Scienc Review**, 1969, 175, **51**, 471. If the latter method is used, car should be taken not to leave the ammoniacal solution, of silver ion standing as explosive fulminating silver will be formed.

f. Di (dodacanoyl) peroxide (lauroyl peroxide)

A small fire of wood shavings can be lit outside and **small** portion at a time added to the fire. Keep the bottle of peroxide at distance and carry the portions to the fire. Alternatively, organi peroxides may be disposed of by adding excess of 10% alkali an leaving for 12 hours before diluting and running to waste.

g. Raney nickel and hydrogenation catalysts

If used they will probably contain adsorbed hydrogen and ma ignite on exposure to air. Place in a safe open site and open the l for 6 hours prior to disposal in a sealed container.

h. Soda lime

Soda lime, used to dry hydrogen sulphide, may ignite in air a should be treated with dilute hydrochloric acid in a fume cupboa prior to sealing in a packet and placing with refuse.

i. Alumina columns

Alumina columns used to removed peroxides in ethers should hav water run through them prior to disposal.

References

1. Health and Safety at Work Act 1974.
2. Control of Pollution Act 1974.
3. The Control of Pollution (Special Waste) Regulations 1980, S No. 1709.
4. The Clean Air Acts of 1956 and 1968 and associated Alka and Works Regulations Acts.
5. Public Health Act 1961.
6. Highly Flammable Liquids and Liquefied Petroleum Gase Regulations 1972, SI No. 917.
7. The Radioactive Substances (Schools etc.) Exemption Order 1963, SI 1962, No. 1832. (These are well interpreted in th appropriate government circular, namely: SED Circular 689
8. Packaging and Labelling of Dangerous Substances Regulations 1978, SI No. 209, as amended 1981, SI No. 792.
9. The Safety Signs Regulations 1980, SI No. 1471.
10. "The Labelling of Chemicals", in **Education in Science**, Apri 1979.
11. Slix RU available from BDH.
12. "Hazardous Chemicals—a Manual for Schools an Colleges", Scottish Schools Science Equipment Researc Centre, (Oliver & Boyd, 3rd impression 1980).
13. Hazcards, CLEAPSE/SSSERC, available from SSSERC.
14. "Hazards in the Chemical Laboratory", 3rd edition, edite by L. Bretherick. (Royal Society of Chemistry).
15. "The Care, Handling and Disposal of Dangerous Chemicals by P.J. Gaston, (Northern Publishers, Aberdeen). Althoug somewhat dated in places, this is a very useful source o information.

Some Useful Addresses

National Radiological Protection Board,
Scottish Centre,
155 Hardgate Road,
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