Health and Safety Checks on Science Texts

Guidance for publishers, authors, editors and readers

The Association for Science Education

CLEAPSS
Supporting practical science & technology
- in schools and colleges

SSERC
Scottish Schools Equipment Research Centre

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1 Who is this document for?

This document is for authors and publishers of science texts that describe practical activities. Members of the Safeguards in Science Committee of the Association for Science Education (ASE)[1], and staff of CLEAPSS [2] or the Scottish Schools Equipment Research Centre (SSERC)[3] are sometimes asked by publishers to check the manuscript of a proposed school science text for health and safety issues. Texts which might need checking include those in which practical activities are suggested, either demonstrations by teachers or hands-on work by students (or pupils) from nursery through to post-16 students (including both GCE A level and equivalent).

This document is intended to

- explain to publishers why a health and safety check might be a good idea;
- outline to editors what such a check would be looking for;
- give guidance for members of the above organisations so that a consistent standard is adopted irrespective of who does the checking;
- help prospective authors write text which is likely to need only a minimum of modification;
- give some guidance to those producing artwork for such texts.

The document, although copyright, may be freely copied by publishers to their own staff, authors, illustrators, etc.

This version, dated May 1999 (with minor updating March 2001 and October 2006), replaces an earlier document produced jointly by CLEAPSS and ASE. It has been extensively revised and re-written in the light of experience with a number of publishers and their authors.

2 Why are health and safety checks necessary?

School science is safe. Serious injuries to students are about a hundred times more likely in PE than they are in science. Interestingly, some of the most serious accidents tend to happen during teacher demonstrations rather than during student practical work. Teachers and technicians may, of course, also be vulnerable to the effects of

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long-term exposure to small amounts of chemicals, although there is little evidence of a problem.

There is a duty under section 6 of the Health and Safety at Work, etc Act 1974 (HSW Act) on anyone who supplies an article for use at work to provide adequate health and safety warnings and advice on any necessary precautions to be observed. Most people are familiar with the types of warning that are seen on a variety of products, ranging from knives to electric appliances. It is unclear whether a text is considered to be an article in the sense intended in this section of the Act. We will not know until it has been tested in court. However, prudent publishers would assume that the Act does apply and include suitable health and safety information. Indeed, stating that there has been a health and safety check would be a strong selling point. Note that in a multi-text project there may be several different audiences, eg, students, teachers, technicians, who may need different health and safety information.

The HSW Act itself is fairly general. However, under the overall umbrella of the Act many regulations have been introduced which give guidance in specific contexts. Amongst the most relevant regulations in the context of school science are the Control of Substances Hazardous to Health Regulations (the COSHH Regulations), the Management of Health and Safety at Work Regulations (the Management Regulations). the Personal Protective Equipment Regulations (the PPE Regulations) and the Chemical Hazard (Information and Packaging for Supply) Regulations (the CHIP Regulations) to name but four.

More importantly, members of the Safeguards in Science Committee of the ASE, and staff of CLEAPSS and SSERC hear of many accidents and near-misses. They know, from experience, what can go wrong in school science. They can often identify potential problems and suggest ways of overcoming them. It is very rarely that readers need to say "Don't do this". Much more commonly they will say "Do it this way".

3 Risk assessment

To simplify a complicated situation, the net effect of the legislation is that employers (usually the local or education authority or the governing body, depending on the type of school) must provide a risk assessment before employees (eg, teachers, technicians) or others (eg, students) undertake hazardous activities, or handle hazardous microorganisms, equipment or chemicals. A risk assessment first involves identifying a hazard, ie, anything with the potential to cause harm, for example, some chemicals, electricity at high enough voltages, samples of microorganisms collected from some environments. The risk is then assessed by considering how likely it is that the hazard will actually cause harm and how serious that harm would be. Control measures (or protective or preventative measures) are then adopted to reduce the risk to acceptable proportions. Such measures might include using a more dilute solution, a less hazardous chemical, a lower voltage, a fume cupboard, taping a culture of microorganisms, etc. In practice, acting on advice originally given in *COSHH Guidance for Schools* (HSC, 1989) and re-affirmed in the *Approved Code of Practice* accompanying the Management Regulations, most education employers adopt various nationally available publications as model (general) risk assessments. Schools are then expected to follow this national guidance, subject only to review and possible minor adaptation to satisfy local conditions. The publications normally used as model (general) risk assessments in secondary schools and colleges are:

- *Topics in Safety*, 3rd edition (ASE, 2001)
- *Safeguards in the School Laboratory*, 11th edition (ASE, 2006)
- *CLEAPSS Science Publications*, CD-ROM (latest edition[4])
- *Safetynet, (SSERC)*[5]
- *Safety in Science Education (DfEE, 1996, available on ASE web site)*

In primary schools, the model (general) risk assessments used are:

- *Be safe! Health and safety in primary school science and technology*, 3rd edition (ASE, 2001)

An author needs ready access to at least some of the above texts but note that CLEAPSS and some SSERC publications are normally available only to those working in member institutions. Negotiation may be possible.

The message is clear. Authors and publishers should generally aim to conform to model risk assessments. As long as authors and/or publishers follow the guidance in these texts, schools should have little difficulty in implementing practical activities and they will be following what is widely regarded as good safe practice, acceptable to employers. It is important to note that these model assessments often suggest age restrictions, eg, only for use by students in Year 9 and above. Sometimes, authors will want to suggest novel activities not covered in model assessments. The health and safety reviewer can offer guidance on how acceptable an activity is likely to be, but in any case the publisher should point out that the activity is not covered by a model risk assessment and warn teachers that they may need to obtain their employers' approval. Employers may well require such special risk assessments to be obtained from CLEAPSS or SSERC. Alternatively, schools may be able to carry out their own risk assessment following guidance, for example, in *Preparing COSHH Risk Assessments for Project Work in Schools* (SSERC, 1991).

4 Role of the author

In the first instance it is for the author to write the text, including any relevant health and safety information. Sometimes, reviewers are left with the impression that an author has ignored health and safety on the grounds that specialist reviewers can add it later. But it should not be an add-on, ie, it should be integral to the text.

The author needs to

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[4] This includes *Hazcards*, the *Laboratory Handbook*, *Recipe Cards*, and dozens of guides and leaflets. Most are available separately if required..

[5] This includes *Hazardous Chemicals CD-ROM* which is available separately.

- give sufficient detail so that the exact nature of the practical work is clear, ie, apparatus, temperatures, concentrations, voltages, quantities, method of working, etc;
- identify all the significant hazards, ie, chemicals (being used or made), microorganisms, equipment, procedures or other hazards;
- where possible, suggest the safest alternative (eg, the lowest workable concentration, less hazardous solvents);
- suggest appropriate control measures (eg, eye protection, safety screens).

The hazard classifications of many of the chemicals likely to be used in school science are listed under the CHIP Regulations but authors will find them most easily in the publications listed in section 3, or in suppliers' catalogues (although catalogues can be inconsistent). Note that the hazard of a solution depends entirely upon the concentration. Appendix C lists the hazards of some commonly used solutions at varying concentrations. If (hazardous) gases are produced then it is particularly important to know, or be able to work out, quantities in case Workplace Exposure Limits may be exceeded. The ability of the apparatus to contain hazardous fumes or dusts may also be important.

Any operation using microorganisms hazardous to health requires a risk assessment. The possibility of contaminant organisms makes it sensible to give adequate precautions for **any** work with microorganisms, including yeasts. Details of suitable precautions and procedures are given in several of the texts listed in section 3.

It would clearly be inappropriate to spell out details of, for example, how to heat test tubes safely on every occasion where test tubes are heated. On the other hand, health and safety reviewers often see examples of unsafe practice, eg, illustrations showing over-full test tubes being heated. In some texts it would be appropriate to include a section on "good laboratory practice." A possible wording is given in Appendix B. Even if a decision is made not to include such a section in the text, authors, artists and editors should be aware of it, as reviewers will regard it as the standard by which texts should be judged.

5 Procedure for reviewing texts

Too often ASE, CLEAPSS and SSERC receive requests to check texts at the last minute. At that stage, it is often too late to do more than a cosmetic check to avoid the most serious problems. Page layout cannot be changed, diagrams cannot be redrawn. Inevitably, if done at the last minute, a botched job is likely to result and ASE, CLEAPSS and SSERC would be reluctant to endorse such a text.

It is much better if health and safety reviewers are involved at the start of a project, before the authors start writing. At that stage, discussions can take place about how any health and safety information is best presented, what type of information should be included and what should go into students' texts or teachers' and technicians' guides. The publisher's brief to the author could include a requirement that health and safety guidance in this leaflet should be followed. We are entirely happy that this leaflet be photocopied widely, as long as it is the latest version, its source is acknowledged and it is copied in its entirety. Any update will be available on the ASE, CLEAPSS or SSERC web sites,

Once a rough first chapter has been drafted, that should be sent for a health and safety check. It is easy to pick up misunderstandings and to set a style which can then be adopted throughout the project. If there are on-going problems, a second chapter might then be submitted, but often it will be sufficient for the author to make one or two phone calls to the reviewer before the final manuscript is submitted.

Publishers sometimes believe that it is best to send the health and safety reviewer the galley proofs (or even page proofs), rather than the author's final manuscript. However, it is much easier to correct layout issues the earlier they are seen. It is vital to have illustrations, as often these are crucial to understanding what the author intends. Often, the students' text does not make sense without an accompanying teachers' or technicians' guide. For example, the students' book may refer to "dilute sulfuric acid". Only when the reviewer knows exactly how dilute the acid is can s/he assess the risk: it could quite easily be CORROSIVE, IRRITANT or LOW HAZARD. Sometimes, the author specifies acid much more concentrated than the reviewer would have anticipated, hence invalidating health and safety comments that the reviewer made at an earlier stage in the student text.

6 Presenting health and safety information in publications

Any health and safety information in a published text must obviously not only be accurate, it must be presented clearly and at a useful point. On the whole, whilst there may be a place for some general health and safety information at the beginning, or in an appendix, we believe that most such information should be presented at the point where the reader is likely to use it. Thus it is **not** a good idea to have a health and safety note **afte**r a set of practical instructions. Inevitably, some readers will only discover them too late. Therefore, such information should appear before the practical instructions, or interspersed with them in some way. If the practical instructions are complex, lengthy or go over a page, then repetition of the information may well be necessary.

There is always a dilemma about how much health and safety information to present. We believe that normally it is most helpful to the reader if publications identify any significant **hazards** and the appropriate **control measures** to reduce the risks from those hazards to an acceptable level. It may be possible to do this quite concisely. Too much information may lead to clutter and a failure to convey important messages.

Some publishers find it helpful to draw attention to health and safety information by the use of suitable signs and symbols. There is no legal necessity to do this, but if signs are used then they should be the internationally agreed symbols (listed, for example, in *Safeguards in the School Laboratory*). If there are lists of chemicals, then it may sometimes be convenient to use the general DANGER symbol (an exclamation mark inside a triangle) in the margin and then use words immediately after the name of the chemical to indicate the hazard(s), eg,

sulfuric acid, 2 mol dm^{-3} (CORROSIVE).

The alternative of putting the CORROSIVE (or any other relevant symbols) may result in clutter if many chemicals are being listed but if a range of signs are used it must be made clear which sign(s) is/are linked to which chemical(s).

Even if there is a teachers' or technicians' guide, some health and safety information will be necessary in a students' book. Firstly, experience shows that teachers often fail to check the teachers' guide, hence some warnings need to be given in the students' book as well. Secondly, the various curricula across the UK require pupils to be taught to recognise hazards and assess risks. A text that failed to contribute to this would be a poor buy. Of course different information may well be in a teachers' or technicians' guide. A technician using solid sodium hydroxide to prepare a solution needs to be warned that the solid is CORROSIVE. The student using, say, a 0.1 mol dm^{-3} solution, needs to be told the solution is IRRITANT. Similarly, if syringes need to be used, the teacher may need reminding of their potential for drug abuse and to count them out and in. This would obviously be inappropriate in the students' book!

It is important that health and safety information should not go over the top. To quote from the Approved Code of Practice which accompanies the *Management of Health and Safety at Work Regulations:* "Do not obscure important information with a mass of trivia." Most chemicals are hazardous - but only if you have too much of them. How much "too much" is depends on the chemical and science educators should be careful to stress this point - to teachers, technicians and students. Copper sulfate, consumed in quantity, can kill. Officially the solid and concentrated solutions (greater than 1 mol dm^{-3}) are classed as HARMFUL, but often the solutions used by pupils would be LOW HAZARD.

It is probably best for publishers to avoid the term "Risk assessment", for that is the responsibility of the employer. If a heading is needed, call it "Health and Safety Notes" or "Health and Safety Information" or some such.

Similarly, it is best to avoid terms such as "safety spectacles" or "safety goggles" in favour of the more general "eye protection". In general, safety spectacles are considered adequate if chemicals classed as TOXIC or CORROSIVE are not in use, but some schools prefer to use goggles giving chemical splash protection all the time. A few employers have required the use of face shields and these may well be necessary for work by technicians, or for pupils with some types of special need (eg, those who are visually impaired, or who have motor difficulties). A risk assessment is needed to determine the appropriate personal protective equipment and the text really needs only to give a reminder. However, when the highest standard of protection is necessary, this should be pointed out.

7 Individual projects, investigations and assignments

Increasingly these days at all levels students may be asked to plan a practical project, investigation or similar. Asking students to identify the hazards, assess the risks from them and choose appropriate control measures may be an important component of the investigation. Students may be expected to look up relevant health and safety information, for example on *Student Safety Sheets* (CLEAPSS[6]). Clearly, in such cases it would be inappropriate to present the information in the text. It may be possible to give some hints, eg, "Show how you will carry out your investigation safely." Even if the student is required to think about health and safety, it is nevertheless vital that the teacher checks the plans before practical work starts. Statements such as "Ask your teacher to check your plans before you start" will help remind students. Of course, after initial tests, plans are sometimes modified. With increasingly large classes, teachers may well find it difficult to supervise everything that is going on. Therefore, it is best if such investigations are carried out in relatively safe contexts. The author needs to consider approaches that students might reasonably be expected to take and consider the health and safety implications.

8 Texts for primary schools

All of the above apply to primary science, although the widespread acceptance of *Be safe!* makes the task of author and reviewer much easier. Hazards need to be identified and appropriate control measures to reduce the risks must be suggested. Work with microorganisms, eg, watching bread go mouldy, requires a risk assessment. Many "kitchen chemicals" are classed as HARMFUL or IRRITANT (or even more hazardous) and thus a risk assessment is again required. Most primary schools do not have class sets of safety spectacles and many of the types on the market are unsuitable as they do not fit small faces well. Therefore, it is usually preferable to avoid suggesting procedures for which eye protection might be required. However, if they are required, authors might need to give guidance on sources of suitably small models.

9 Common pitfalls

Time and time again, health and safety reviewers find authors falling into the same traps. These are some of the commoner ones to avoid.

- ***Going over the top on safety***. Surprisingly often, authors are over-cautious, giving excessive health and safety warnings, exaggerating the hazards of the chemicals or procedures being used and suggesting unnecessary control measures. Some judgement needs to be exercised - an appropriate warning for 11 year olds may be way over the top for post-16 students . Protective gloves are not necessarily a good idea: glassware is more likely to slip and gloves may engender a degree of recklessness. Benedict's Solution, as usually made up, is low hazard - and certainly not corrosive. It does not help anybody if pupils become fearful of chemicals,

[6] On the latest CLEAPSS *Science Publications* CD-ROM

microorganisms, radioactive materials, etc: the role of science education should be to help young people put the hazards, and the risks from them, into perspective. This requires accurate information.

- ***Vague health and safety warnings***. Whilst it may well be helpful to use the general danger symbol (exclamation mark in a triangle) to draw attention to a hazard for which there is no specific symbol, it is **not** helpful to add the comment "Care needed". Be specific, by pointing out what the hazard is and what steps the reader needs to take.

- ***Diagrams need safety checks***. Sometimes, instructions for a practical activity do not make sense without the accompanying diagram. Too often an artist, working from a somewhat imprecise brief, draws a diagram illustrating poor practice.

- ***Activities inappropriate for the age range.*** Sometimes an activity is acceptable in principle, but is suggested for use by too immature an age group. Younger pupils may lack the practical skills, experience or self-control to carry out an activity in a healthy and safe manner. Clearly much depends on the nature of the pupils and the extent of the supervision which it is possible to exercise, but most of the model (general) risk assessments listed in section 3 do include suggested age restrictions. Authors are advised to stick to these suggestions, but if they really want an activity to be carried out by a younger age group than is recommended, then they need to point out that this is the case.

- ***Dilute solutions*** can cover a multitude of concentrations. Whilst it may be legitimate to use the term "dilute" in the students' book, in the teachers' or technicians' guide the concentration must be spelled out. This is only useful to the reviewer, of course, if both texts arrive at the same time. Do not make the mistake of assuming that just because the author's school normally uses, say, 1 mol dm^{-3} sodium hydroxide, every other school does as well.

- ***Use the lowest concentration*** possible. Just because 2 mol dm^{-3} sulfuric acid has been traditionally used for the last hundred years does not mean that 0.2 mol dm^{-3} might not work just as well - and be both safer and cheaper.

- ***Quantities must be specified.*** The author's “small amount in a test tube” might be 0.2 g, the reader's might be 2 g. If heating the chemical produces a toxic gas, for what the author can do safely in the open laboratory, the reader might need a fume cupboard.

- ***Use the safest alternative.*** Under the COSHH Regulations, where alternatives exist, you are obliged to use the safest practicable alternative which achieves your educational objective.For example, in some contexts, solvents such as cyclohexane or Volasil 244 will be safer alternatives to trichloromethane (chloroform).

- ***Chemical problems aren't confined to chemistry***. Biologists and physicists also use chemicals and often know a good deal less about their hazards than their chemistry colleagues.

- ***It's not just chemicals that need eye protection.*** Eye protection needs to be worn whenever there is any risk to the eye. Stretching nylon filaments to breaking point can result in eye damage if the filament whips across the face.

- ***Warn about radiation hazards,*** Too often there are no warnings about the fire dangers from infra-red heaters, the need to screen ultra-violet sources from direct view, the risks of directly viewing the sun or the safety precautions to be observed when using lasers.

- ***Heating ethanol, industrial denatured alcohol, etc.*** Ethanol fires have been a major problem in school science. Whilst some teachers are able to ensure that Bunsen burners are turned off before highly flammable liquids are dispensed, this is becoming more and more difficult with increasing class sizes. Therefore, it is best to avoid using ethanol etc in the same lesson as Bunsen burners. If hot ethanol is required, an electric kettle is a good source of hot water, as is a thermostatically-controlled water bath.

- ***Use the lowest possible voltage.*** In procedures as diverse as electrophoresis or the high-voltage transmission line demonstration, either use voltages below 40 V dc (or 28 V ac), or make sure there is a safety interlock or that any live components are enclosed in such a way that they cannot be inadvertently touched. At the very least, shrouded plugs are necessary.

- ***Capacitors can present hazards***. Large capacitors can store sufficient energy to deliver an unpleasant electric shock. Electrolytic capacitors can explode if connected with the wrong polarity, with a current overload or if a voltage higher than the rated capacity is applied.

- ***Heavy loads are hazardous.*** Heavy loads might include large, heavy and unwieldy trolley runways as well as falling masses. Remember that manual handling injuries cause more absence from work than any other single cause. A waste bin or bucket (filled with waste paper) underneath a stretching wire can both keep toes out of the way of a falling load and cushion the fall if the wire breaks. Remember, however, that high voltages can be fatal but falling loads in physics laboratories are less likely to be so.

- ***Incubation temperatures*** These are often not specified, or are inappropriate. Generally avoid temperatures near to body temperature (37 degrees C) so as not to encourage the growth of organisms pathogenic to humans. Room temperature is often satisfactory.

10 Timing and payments

Members of the Safeguards in Science Committee of the Association for Science Education (ASE), and staff of CLEAPSS or the Scottish Schools Equipment Research Centre (SSERC) have full-time jobs, which do not usually include checking manuscripts for health and safety. Membership of the Safeguards in Science Committee is an unpaid, voluntary activity. Any health and safety checking will have to be fitted into the evenings and weekends and will have to find its own place in an individual's priorities. Some health and safety reviewers are examiners and thus dead to the world for several weeks in the summer. Just because somebody reminded an editor two weeks before a text was due to go to press that a health and safety check might be a good idea does not make it a priority to the reviewer who may well have other commitments.

ASE, CLEAPSS and SSERC are the leading experts on health and safety in school science throughout the UK. They are happy to share their expertise with publishers in the interests of promoting good practical science. They are aware that school publishing is not a goldmine. Nevertheless, health and safety reviewers will expect remuneration commensurate with their professional expertise.

11 Acknowledgement of a health and safety check

Most publishers will want to put in some form of statement to indicate that a health and safety check has been carried out. The wording needs to be agreed with the reviewer. If the review has been carried out at a late stage, reviewers may feel reluctant to endorse something where there has had to be significant compromise over what would be preferred. Equally, however, if the review was carried out on an early draft the reviewer has no way of knowing whether her/his advice was acted upon. A Model Health and Safety Statement is given in Appendix A.

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Safeguards in Science Committee,
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CLEAPSS

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Appendix A: Model health and safety statement

Where a health and safety review has been carried out, the publisher will usually want to acknowledge this. The following is suggested as a possible form of words, although the detailed wording will need to be negotiated with the reviewer.

> We have attempted to identify all the recognised hazards in the practical activities in this text, provide suitable warnings about them and suggest appropriate precautions. Teachers and technicians should remember, however, that where there is a hazard, the **employer** is required by health and safety regulations to make a risk assessment. Most education employers have adopted a range of nationally available publications as model (general) risk assessments and, where such published assessments exist for the activity, our advice is believed to be compatible with them. Nevertheless, teachers and technicians must check whether what is proposed is indeed compatible with the requirements of the employer. In a few cases, activities may be included which are not covered by widely-used model risk assessments. We have tried to identify these and in such cases teachers or technicians may need to check with their employer whether the activity is acceptable. If a member, the employer will often suggest consulting CLEAPSS or, in Scotland, SSERC. The proposed activities are likely to be acceptable to these organisations.
>
> Even where an activity is broadly in line with a model risk assessment, staff in a school will still need to consider whether their particular situation requires any adaptation.
>
> We have assumed that practical work is carried out in a properly equipped and maintained laboratory and that any field work takes account of the employer's guidelines. In particular, we assumed that any mains-operated electrical equipment is properly maintained, that pupils have been shown how to conduct normal laboratory operations (such as heating or handling heavy objects) safely and that good practice is observed when chemicals or living organisms are handled (see Appendix B). We have also assumed that classes are sufficiently small and well-behaved for a teacher to be able to exercise adequate supervision of the pupils and that rooms are not so crowded that pupils' activities pose a danger to their neighbours.
>
> (A) member(s) of the (ASE Safeguards in Science Committee)/(staff of (CLEAPSS)/(SSERC)) has/have read this text. In the draft which was checked, the health and safety reviewer either advised the publisher that the text did conform to the above policy or gave guidance on how to make it conform.

Appendix B **Good Laboratory Practice**

The following statement, or something like it, could usefully appear in texts where there is practical work, although parts might be omitted depending on the content of the text in question. Note that biology and physics texts often include activities in which chemicals are used. It will also give some **guidance to authors** when giving instructions for practical work, or **those producing artwork** to illustrate such activities.

A brief statement such as this can only be a summary. Any guidance issued by your employer must be followed, whatever is suggested here.

It is expected that every school will have rules governing behaviour in the laboratory. No eating or drinking (or indeed smoking or the application of cosmetics) should be allowed in laboratories. Interference with mains services or equipment should be strictly forbidden, as should running or foolish behaviour generally.

Good hygiene is needed at all times, but especially when chemicals or living organisms are being used. Benches need to be wiped down after such activities and hands washed.

Suitable eye protection must be worn whenever the risk assessment requires it, ie, whenever there is a recognised risk to the eyes. This will certainly include activities in which chemicals are heated, heat is generated in a chemical reaction or any activities involving chemicals with a hazard classification. Eye protection is also necessary where there are mechanical hazards, eg when stretching wires to breaking point or evacuating vessels.

Many accidents occur during heating activities. Long hair should be tied back and ties, cardigans, scarves, baggy shirts, etc should not be allowed to hang freely. It is assumed that teachers will show and remind students how to heat safely small quantities of solids in test tubes and liquids in boiling tubes (wide diameter test tubes), using small quantities so that the tube is not more than 1/5th full, and pointing the tube away from their own faces and other peoples' faces. The tube should be sloping so that the holder is not in a flame. For liquids, tubes should be gently shaken or a water bath used where appropriate. Students should stand, not sit, for most operations in which chemicals (and especially liquids) are handled.

Teachers will need to show students how to smell the contents of a test tube or bottle safely. First, fill the lungs with (ordinary) air by breathing in deeply (so that only a small amount of chemical can be subsequently sniffed in.) The test tube etc should then be held some distance from the face and pointing away from it, and the odours wafted gently towards the nose with a hand.

Students need to be shown how to pour safely from bottles, pouring away from the label (so that it is not damaged by drips). Spills of chemicals should be wiped up at once. Some may require chemical treatment (eg, neutralisation) but, in the quantities normally handled by students, a damp cloth is usually sufficient. The cloth should then be rinsed. Students should be trained to use a spatula or similar device and never to handle chemicals with their fingers. Wherever possible, teat pipettes should be avoided. Even with well-behaved classes, too many accidents occur when liquids are squirted from them, eg, when clearing up at the end of a lesson. Except sometimes in the sixth form, work in schools rarely requires the use of protective gloves. However, when chemicals have been used or living organisms handled, students should be trained to wash their hands afterwards.

If the risk assessment requires the use of a fume cupboard, then this should meet the standard of *Building Bulletin 88, Fume Cupboards in Schools* (Architects and Buildings Branch, DfEE, 1998, HMSO) (previously *Design Note 29*).
If safety screens are required for a demonstration, then they should be sufficient in number to protect both the teacher and all the students. They should be sufficiently tall and sufficiently close to the apparatus to prevent objects going over the top. There should be a gap of 2 m or more between any demonstration and the students.

If microorganisms are in use, teachers unfamiliar with modern techniques may need training (see for example, *Topics in Safety*, *Safety in Science Education* or the *CLEAPSS Laboratory Handbook*). In any work in micro-biology, risks can be reduced to an acceptable level by observing good practice and following simple precautions. Sterile technique is needed to prevent cultures from becoming contaminated and to stop microorganisms escaping from cultures. This will involve ensuring that materials which will contact microbes are sterile before and afterwards; a pressure cooker or autoclave is essential, complemented by the use of appropriate chemical disinfectants to deal with spills and to clean working surfaces. By choosing appropriate organisms and growth media, avoiding the culture of microbes from dangerous sources and incubating at room temperature, together with the correct handling and sealing of cultures, exposure to pathogens can be minimised or eliminated. The culture of organisms that will be consumed, eg, yoghurt bacteria or baker's yeast, should not take place in a science laboratory.

Appendix C: **Hazards of common laboratory solutions at various concentrations**

Reagent / solution	***Concentration.*** For convenience, the letter M has been used for the unit mol dm^{-3}	***Hazard***
Ammonia	6 M or more 3 M* or more but less than 6 M	CORROSIVE IRRITANT
Barium salts	0.05 M* or more	HARMFUL
Benedict's Reagent	typical formulation	HARMFUL PRODUCT
Biuret solution A	typical formulation, 2 M sodium hydroxide if less than 0.5 M sodium hydroxide	CORROSIVE IRRITANT
Bromine water	0.06 M or more 0.006M* or more but less than 0.06M	TOXIC & CORROSIVE HARMFUL & IRRITANT
Copper(II) chloride	1.4 M or more 0.15 M* or more but less than 1.4M	TOXIC HARMFUL
Copper salts *except* chloride	1 M* or more	HARMFUL
Ethanedioic acid and ethanedioates	0.3 M* or more	HARMFUL
Ethanoic (acetic) acid	4 M or more 1.5 M* or more but less than 4 M	CORROSIVE IRRITANT
Fehling's solution B	typical formulation, 4 M sodium hydroxide	CORROSIVE
Hydrochloric acid	6.5 M or more 2 M* or more but less than 6.5 M	CORROSIVE IRRITANT
Hydrogen peroxide	5.9 M or more (>71 vol)* 1.5M* or more(>18 vol) but less than 5.9M	CORROSIVE IRRITANT
Indicators	if made up in ethanol etc	HIGHLY FLAMMABLE
Iodine	1 M* or more	HARMFUL
Iron(II) salts (ferrous)	1 M* or more	HARMFUL
Iron(III) salts (ferric)	0.75 M* or more	IRRITANT
Lead salts	0.01 M or more 0.001M* or more but less than 0.01M	TOXIC HARMFUL
Mercury salts	0.004 M or more 0.002 M* or more but less than 0.004 M	TOXIC HARMFUL
Methanal (formaldehyde)	25% or more 1%* or more but less than 25%	TOXIC HARMFUL
Nessler's Reagent		TOXIC
Nickel salts	0.5 M* or more	HARMFUL
Nitric acid	0.5 M or more 0.1M* or more but less than 0.5 M	CORROSIVE IRRITANT
Phosphoric acid	2.5 M or more 0.1M* or more but less than 2.5 M	CORROSIVE IRRITANT
Potassium or sodium chromate or dichromate	0.2 M or more 0.003 M or more, but less than 0.2 M	VERY TOXIC TOXIC
Potassium hexacyanoferrates (ferro- or ferricyanides)	any	LOW HAZARD
Potassium hydroxide	0.5 M or more 0.05 M* or more but less than 0.5 M	CORROSIVE IRRITANT
Potassium manganate(VII)	any	LOW HAZARD
Silver nitrate	0.5 M or more 0.2 M* or more but less than 0.5 M	CORROSIVE IRRITANT
Sodium chlorate(I) (hypochlorite)	10% or more available chlorine 5%* or more but less than 10% av. chlorine	CORROSIVE IRRITANT
Sodium hydroxide	0.5 M or more 0.05 M* or more but less than 0.5 M	CORROSIVE IRRITANT
Sodium nitrite	0.7 M or more 0.1 M* or more but less than 0.7 M	TOXIC HARMFUL
Sulfuric acid	1.5 M or more 0.5 M* or more but less than 1.5 M	CORROSIVE IRRITANT
Zinc sulfate	1M or more*	IRRITANT

* For concentrations less than those mentioned, no symbol is required.
The pure solute will generally present the same hazard as the most concentrated solution listed above.
For named reagents, there are often quite wide variations in the formulation.