CLEAPSS

STUDENT SAFETY SHEETS

Combined issue, 2009

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STUDENT SAFETY SHEETS

Contents (Combined, all issues, 2009)

STUDENT SAFETY SHEETS

Summary

The CLEAPSS *Student Safety Sheets* are intended to:

- support the teaching of health & safety in the National Curriculum, especially at KS4 and in vocational courses;
- be used as a 'pupil-speak' version of CLEAPSS Hazcards;
- encourage pupils to think about health & safety in a guided way.

The *Student Safety Sheets*

- include non-chemical hazards, examples from everyday life and a *Teachers' Guide* giving ideas for use;
- are available on the CLEAPSS *Science Publications CD-ROM*. Minor alterations and updates will be available on the CLEAPSS web site until they have been incorporated into a new version on a subsequent CD-ROM.
- may be freely photocopied or modified, eg, for lower-ability groups within members' establishments.

The *Sheets* might be made available in a variety of ways, for example as:

- individual sheets issued when required;
- a stapled reference booklet in every laboratory;
- a class set of booklets issued when required;
- enlarged individual sheets, possibly laminated, and displayed on walls.

Uses for the *Sheets* by students include:

- general reference in the laboratory;
- raising awareness before starting a topic;
- a resource when planning a practical investigation;
- as materials for a comprehension exercise or for developing information skills;
- reviewing health & safety in a practical activity to be carried out;
- a resource for homework exercises, including home safety surveys.

Purpose of the CLEAPSS *Student Safety Sheets*

The Programme of Study for the National Curriculum in Science, in Key Stage 4 (2006) includes, in *How Science Works*, a requirement that:

pupils should be taught to work accurately and safely, individually and with others, when collecting first-hand data.

The current draft of the new programme of study for Key Stage 3 states that:

> *Pupils should be able to:*
> *Assess risks and work safely in the laboratory, field and workplace, …*

It remains clear that pupils must be taught about health, safety and risk assessment in their study of secondary science.

Many science text books now routinely provide some health & safety information and guidance. However, it is usually closely matched to the activities in the text and not easily interpreted by pupils engaged on different or even related practical activities. Some schools have reported that they allow pupils to use CLEAPSS *Hazcards* and sometimes other similar model (or general) risk assessments. However, these were never written with pupils in mind, contain information which is at best irrelevant to them and which, in some cases, it might be undesirable for them to see. Their style makes them inaccessible to many pupils. The CLEAPSS *Student Safety Sheets* have been written in an attempt to meet the need for a systematic, coherent and accessible information source.

The *Student Safety Sheets* are intended to be a 'pupil-speak' version of the CLEAPSS *Hazcards*. However, they have been simplified, reorganised and expanded to cover some non-chemical hazards and situations other than those found in school science. In addition, some guidance is given on how pupils might assess risks involved in practical activities. Although most of the *Student Safety Sheets* refer to chemicals, equipment etc that pupils might themselves use, some refer to those they would NOT use. This is quite deliberate in order to help expand students' understanding and appreciation of how science works.

This set of *Student Safety Sheets* is specifically targeted at pupils at Key Stage 4 although, in trials, some sheets were used with Y9 pupils and in post-16 courses.

Teaching students to assess risks

It is important to stress that the provision of risk assessments is the responsibility of the employer; a departmental health & safety policy should make this clear. (Further details are found in the CLEAPSS Guide L196, *Managing Risk Assessment in Science*, 2005.) Nevertheless, students can be taken through the thinking process involved in assessing risks and this will help them not only satisfy the requirements of the National Curriculum but also prepare them for coping with hazards in the home, in the environment and in the world of work. The Health and Safety Executive reports that a high proportion of the serious accidents which happen at work involve young people in their first job, on training schemes or on work experience. By encouraging pupils/students to think about hazard and risk in a systematic way, science may contribute to their safety education. **Teachers in the trials reported that pupils appreciated being involved in thinking about and discussing safety in real contexts, rather than just being told what to do.** (But beware in case they become over-concerned.)

A **hazard** is anything with the potential to cause harm, so, for example, many chemicals present hazards, as do some microorganisms and electricity at high voltages. Cluttered floors, over-crowded benches and working up ladders are also hazards.

A **risk** is the likelihood of harm actually being caused. This involves judging how likely it is that something would go wrong and also how serious the consequences would be. A hot tripod presents a hazard. The risk from it is relatively low because although it is quite likely that somebody will pick one up, the consequences - a minor burn on the fingers - are not generally serious.

Risks are reduced by adopting **control measures** (ie, taking precautions). These might, for example, involve using a more-dilute solution, wearing personal protective equipment (although this should be used as a last resort if the activity cannot be made safer) or, in the case of the hot tripod, reminding students that picking up hot objects is not a good idea!

It is important to stress that no activity is completely safe. Even when lying in bed at night there is a small risk that a satellite might come crashing through the roof! You could reduce the risk by spending a lot of money on building an extra-strong roof but nobody would ever think that the risk was large enough to justify the money. It is true, however, that some risks (eg, in sport) seem more acceptable to the public at large than others (eg, nuclear power).

Students can be taught the basic procedure of **assessing risks**.

- **What are the details of the activity to be undertaken?**
- **What are the hazards in this activity?**
- **What is the chance of something going wrong?**
- **How serious would it be if something did go wrong?**
- **How can the risk(s) be controlled for this activity?**

The CLEAPSS *Student Safety Sheets* will help students identify the hazards and risks associated with a range of activities, mainly, but not entirely, in the school laboratory and hence suggest appropriate control measures. Of course, in many cases a full risk assessment would require detailed calculations, for example, about exposure to air-borne chemicals, and this is not likely to be appropriate for most students in KS4, although a few figures are included for those aiming at A and A* grades.

About the CLEAPSS *Student Safety Sheets*

CLEAPSS *Student Safety Sheets* are available free of charge to each institution with pupils at KS4 or in the 6th form in local authorities which are members of CLEAPSS, and to independent schools and colleges which are associate members. These establishments are then free to copy the *Sheets* for use by their pupils but they are **NOT available to non-members of CLEAPSS**. As long as the integrity and accuracy of the safety information is preserved, teachers may, if they wish, amend the *Sheets* for example by deleting some parts, to meet the needs of pupils of varying abilities and we would encourage them to do so. When modifying the *Sheets,* we suggest schools first make copies rather than using the originals! However, there is a customisable version of the *Sheets* on the CLEAPSS *Science Publications CD-ROM*. ***CLEAPSS would appreciate receiving copies of any amended sheets together with information on how they are used***. Please send such sheets to Bob Worley at CLEAPSS, The Gardiner Building, Brunel Science Park, Kingston Lane, Uxbridge UB8 3PQ.

All the *Student Safety Sheets* follow the same basic layout. We think this will help students to find the information they need but it does impose some constraints and means that some sheets end up rather crowded. In the trials, some schools simplified the *Sheets*, for example by missing out the *Emergency Action* section before photocopying. Each *Sheet* includes the following elements.

- **A table summarising the hazards** of a series of related substances, eg, a gas and solutions of it at various concentrations. There is usually a comment about effects on the human body and sometimes other particular problems. Where appropriate, we have tried to include some examples from outside school science (but would welcome further suggestions). The hazard often depends on the concentration. We have described both the concentration in words (eg, 'moderately concentrated') and given a molarity, M (mol dm^{-3}). Teachers may wish to Tippex out the molarity but then there will be some ambiguities in the descriptions.

- **A list of typical control measures** which can be taken to reduce the risk from these substances. Not all will be appropriate in any particular situation. Students will have to exercise some judgement in deciding which are the most relevant in the activity they are thinking about. We have tried to be reasonably comprehensive but there could be other control measures in some cases.

- **A series of questions about assessing the risks.** These questions are the same on every *Sheet*, although the examples given in small print are specific to each *Sheet*. These are intended to take the student through the thinking process in assessing risk - the process should be the same for any hazard and the risks arising from it (see earlier discussion for more details). During the trials, some teachers felt that these questions might be removed from the *Sheets* and put on a separate page. The 'small-print' examples would then be lost but, if any school does experiment with this approach, we would be interested to hear the outcomes.

- **Guidance on emergency action** which includes information specific to the *Sheet*, for example dealing with fires, spills, chemicals in the eye, etc. Some teachers in the trials felt that this could be removed to make the sheets less cluttered.

We have deliberately included some quantitative data, for example, molar concentrations of solutions and permitted concentrations of air-borne chemicals, in order to provide ideas which are stimulating for the most able. We recognise this may be off-putting for some youngsters but hope the layout is such that it should be easy to use correcting fluid to remove such data if required or, preferably, amend the customisable version of the *Sheets*.

The *Student Safety Sheets* are numbered and grouped so that related hazards have adjacent numbers. Thus acids are on sheets 20, 21, 22... . This may help searching, although there is an *Index*. The classification is somewhat arbitrary and there are many apparent gaps to leave space for further *Sheets* that may be issued later. Vocabulary and Safety Signs sheets are also provided.

How to use the CLEAPSS *Student Safety Sheets*

As risk assessment is the responsibility of the employer, **from the point of view of students, assessing risks is a simulation exercise**. The fact that students have used the *Sheets* to check hazards and assess risks does **not** absolve the teacher from the task of ensuring that what the student proposes to do in a practical activity is in fact in accordance with the employer's risk assessments.

The *Sheets* may be made available in a number of ways.

- A relevant *Sheet* is issued to accompany a particular practical activity or written exercise.
- The whole set is printed and the *Sheets* stapled together as a class set of booklets to be issued when needed.
- A reference set is provided in each laboratory (possibly laminated or colour-coded).
- Particular sheets are enlarged and laminated for laboratory display.

Some possible ways of using the *Student Safety Sheets* include the following.

- To practice skills of extracting information, for example, using the *Index*, *Vocabulary* and *Safety Signs Sheets* in conjunction with the chemicals or subject *Sheets*.
- For students to check hazards before routine, illustrative practical work.
- To help students in planning practical investigations.
- In written exercises (in class or for homework) for which students are asked, for example, to state why particular safety precautions are used, or what precautions they would use if they were carrying out an activity.
- To stimulate whole-class or small-group discussion (eg. comparing the *Emergency Action* instructions with existing posters outlining procedures).
- To help students assess risks in non-laboratory situations (eg, chemicals in the kitchen, electricity in the home, pollution hazards of car exhausts).

One of the strategies suggested for teaching about hazard and risk was the use of a form for assessing risks. This might be issued as a blank to students, or partially completed, for them to fill in the gaps. Blank forms are included on pages 10, 12 and 13, with a completed example showing the use of *Student Safety Sheets* on page 11. Excessive writing might be avoided if there were tick boxes for *Eye protection*, *Fume cupboard* and other common safety measures, although this might lead to stereotyped answers.

We also include examples of ideas for using the *Sheets,* some of which emerged in the trials. For some purposes, you may want to combine information from several sheets. For example, one school in the trials simply copied the tables at the top of each of the acid sheets and put them onto one page in preparation for some work on acids. Another is considering using *Safety Certificates* for pupils' portfolios. Feel free to adopt or adapt these ideas, or to come up with new ones of your own (but ***we would appreciate receiving a copy so that we can pass on your ideas to others***).

Example 1

For classes of low-attaining pupils, pupils with special needs or early bilinguals, make a series of cards with names of particular chemicals (perhaps relevant to an activity that is about to be carried out). Make another series of cards (colour-coded?) with the hazards (or hazard symbols). Pupils then match these. Use of the Index *and* Contents *pages and the* Vocabulary *sheet will also help to develop information-seeking skills. The* Vocabulary *sheet might be translated into home languages.*

Example 2

Students might be given access to Sheet 11, Radioactive Materials*, together with the following task.*

Smoke alarms used at home have a small radioactive source in them.

Either:

(a) Imagine that a popular newspaper has just discovered this fact and has written a sensationalist article with the headline:

RADIATION HORROR IN YOUR HOME.

You are employed by the manufacturer of smoke alarms and have to write a letter to the paper explaining that these are in fact safe to use.

Or:

(b) You are employed by the manufacturer of these smoke alarms and have to write a safety leaflet to include in the package, explaining that users should not be worried by the fact that the alarm has the word RADIOACTIVE stamped on it.

Example 3

Students might be given the following plan of a proposed practical investigation and asked to:

- *identify the hazards in the activity;*
- *decide how likely it would be for each hazard that something could go wrong;*
- *decide how serious it would be for each hazard if something did go wrong;*
- *rewrite the plan, changing it where necessary, to include the appropriate control measures (ie, precautions to be taken) to reduce the risks.*

I am going to investigate the idea that soap is not very effective for removing bacteria from your hands.

I will get some Petri dishes and pour agar jelly into them. I will use the toilet and then I will press my fingers onto the jelly in one of the dishes. I will then wash my hands with soap and water and press my fingers onto the jelly in another dish. Finally, I will pour some bleach over my fingers and again press my fingers onto the jelly in a third dish. I will leave a fourth dish without any finger prints, as a control.

Then I will put lids on the dishes and take them back to the laboratory. I will put them in the incubator set at 37 °C. Next lesson, I will take the dishes out of the incubator, take off the lids and compare the amount of bacteria growing on each dish.

In the trials, for higher-attaining groups, one school simply copied the above onto the top of a sheet, with room for rewriting below. For lower-attaining classes, the statement was copied, with areas of concern highlighted (e,g 'use the toilet'). Each of the areas was then listed and pupils had to explain why it needed to be altered.

Another school used this as an introduction to a topic on Microbiology.

Example 4

A sheet that might be used for homework.

In the next lesson, we will be carrying out the electrolysis of copper sulfate solution. That means we have to pass an electric current through a solution of copper sulfate. Use *Sheet 40, Copper and its compounds* to answer these questions:

(a) For 0.1 M copper sulfate, how much of a hazard is it?
(b) What could go wrong (eg, swallowing the solution)? How likely would this be in your class? How serious would any accident be?
(c) Can the risk be reduced by changing the chemicals or the procedure? Will the experiment still work?

Now work through the questions again, using *Sheet 10, Electricity* and thinking about the 6 V power supply, rather than the copper sulfate.

Example 5

Most students should be able to identify the hazards in the following procedure and suggest precautions [parts (a) and (b), but only the higher attainers will be able to cope with the calculations, especially part (e) onwards].

You can make ammonia gas by warming ammonium chloride crystals with sodium hydroxide solution in a test tube. Ammonium chloride solid is classified as HARMFUL.

(a) What are the hazards of the other chemicals used or made in this reaction?
(b) What control measures (safety precautions) would you suggest if this activity was to be done in your class?

The equation for the reaction is:

$$NH_4Cl(s) + NaOH(aq) = NaCl(aq) + H_2O(l) + NH_3(g)$$

(c) What mass of ammonia (in grams) could you obtain from 1 g of ammonium chloride?
(d) If each group in your class used 0.5 g ammonium chloride, what mass (in grams) of ammonia would the whole class produce?
(e) What mass of ammonia in **mg** would the whole class produce?
(f) Estimate or measure the volume of your laboratory (in m^3).
(g) Calculate the concentration of ammonia (in mg m^{-3}) in the room that would result from the whole class experiment.
(h) Now compare this concentration with the exposure limit on *Sheet* 30, *Ammonia*. What conclusion do you draw from this?
(i) The calculation assumes the room is completely sealed. Do you think this is justified and, if not, what difference will this make?

Example 6

When students are learning about preparing salts, the class might be divided into, say, six groups and told that salts can be made by the action of a suitable acid on an oxide or carbonate. Two groups of pupils could then be asked to look at the preparation of copper sulfate, one starting from copper oxide, the other from copper carbonate. Similarly for copper chloride and nitrate. Using the relevant Student Safety Sheets, *pupils could be asked to prepare a poster presentation of the method they would use, emphasising and explaining the control measures they would use to reduce the risks. Some of the ideas they might come up with are given on the completed* Student Form for Assessing Risk (page 11). *They might be given a partially-filled-in version of this form to complete for homework, as a way of consolidating what they have learnt.*

Example 7

Here is an example of a set of instructions for teachers taken from a school's Scheme of Work. Thanks to the school which submitted it.

Preparation of salts **Teachers' Notes**

When students are learning about salt preparation, they should assess the risk using CLEAPSS *Student Safety Sheets* and the *Student Form for Assessing Risk*.

Give out the sheet on the general method of salt preparations. Outline that there are various methods of making soluble salts, ie, oxide + acid, carbonate + acid, and that the particular salt made will depend upon which acid is chosen. Split the class into groups and allow them to decide which copper salt they will make. They must assess the risks taking into account the nature of the reactants and the salt to be made as well as any hazards arising from the procedure, eg, heating acids. A model answer prepared by CLEAPSS is included on page 11.

Students should then produce a poster of the method they would use, emphasising and explaining the control measures to reduce any risks.

Alternatively, the *Student Form for Assessing Risk* is on the computer network. There is an opportunity here for some IT - students can type their answers directly onto the form.

Example 8

One school has taken up the suggestion of issuing a Science Safety Certificate. A copy appears on page 9. Our thanks to the school.

Examples 9, 10

There are two further suggestions for the Student Form for Assessing Risk *- on pages 12 and 13. Again, thanks to the teachers who submitted these forms.*

SCIENCE SAFETY CERTIFICATE

Name .... **Form** ....

I can carry out the following with due regard to safety.

	Teacher's signature	*Date*
Behave sensibly during practical sessions		
Wear safety spectacles or goggles when appropriate		
Recognise and understand the hazard symbols		
Control a Bunsen burner		
Heat a liquid in a boiling tube		
Heat a liquid in a beaker using a tripod and gauze		
Locate the position of the eye wash in the laboratory		
Measure and pour dilute acids		
Deal with an acid spill		
Check that mains plugs have the correct fuse & are correctly wired		
Explain why each of the Lab Safety Rules is needed		

Remember to put this Certificate into your portfolio.

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Student Form for Assessing Risk

Proposed practical activity: ....

Name(s) of pupil(s) completing form: ....

Class / set: .... **Date:** ....

Hazardous chemical or microorganism being used or made, or hazardous procedure or equipment	Nature of the hazard(s)	Source(s) of information	Control measures to reduce the risks

Checked by: .... **Date:** ....

Student Form for Assessing Risk

Proposed practical activity: *Making copper sulfate crystals from copper oxide or copper carbonate.*

Name(s) of student(s) completing form: ....

Class / set: .... **Date:** ....

Hazardous chemical or microorganism being used or made, or hazardous procedure or equipment	Nature of the hazard(s)	Source(s) of information	Control measures to reduce the risks
(1) Sulfuric acid	(1) Acid is corrosive if 1.5 M or more; irritant if 0.5 M or more.	(1) Bottle label; CLEAPSS Student Safety Sheets.	(1) Use lowest possible concentration, 0.5 M; wear eye protection.
(2) Copper carbonate	(2) (a) The solid is harmful if swallowed and dust irritates lungs and eyes.	(2) (a) Bottle label; CLEAPSS Student Safety Sheets.	(2) (a) Avoid raising dust; wear eye protection.
	(b) When the reaction takes place, tiny bubbles of carbon dioxide are formed which may produce a spray of sulphuric acid as they burst.	(b) Text book; teacher.	(b) Keep face well away from reaction; wear eye protection.
(3) Copper oxide	(3) (a) The solid is harmful if swallowed and dust irritates lungs and eyes.	(3) (a) Bottle label, CLEAPSS Student Safety Sheets.	(3) (a) Wear eye protection,
	(b) Unlike copper carbonate, copper oxide needs to be heated so mixture may boil over, spill hot acid, etc.	(b) Teacher; text book.	(b) Control Bunsen-burner flame, stir to speed dissolving.
	(c) Hot tripods, etc.	(c) Teacher; past experience.	(c) Pay attention.
(4) Copper sulfate	(4) Solid and solutions more concentrated than 1 M are harmful.	(4) CLEAPSS Student Safety Sheets.	(4) Wash hands after activity. When solution is standing to crystallise label it carefully.
(5) Evaporating solution to form saturated solution	(5) (a) Solution may boil over, or start spitting when nearly saturated.	(5) (a) Teacher; past experience.	(5) (a) Keep careful watch over Bunsen burner. Do not evaporate too much - allow to crystallise slowly. Wear eye protection.
	(b) Hot tripods, etc.	(b) Teacher; past experience.	(b) Pay attention.
	(c) Process is slow, leading to rushing at end of lesson and accidents.	(c) Teacher; past experience.	(c) Use small volume, so it is quicker.

Checked by: .... **Date:** ....

CLEAPSS

Student Form for Assessing Risk

Proposed practical activity: ....

Name(s) of student(s) completing form: ....

Class / set: .... **Date:** ....

A **hazard** is anything which could cause harm, eg, a hot tripod, a cluttered floor.

A **risk** is the likelihood of harm actually being caused.

Use the *Student Safety Sheets*, the practical instructions and the labels on the bottles to fill in this form.

Hazardous chemical or procedure	Type of hazard	Control measures to reduce the risk

Checked by: .... **Date:** ....

Student Form for Assessing Risk

Proposed practical activity: ....

Name(s) of pupil(s) completing form: ....

Class / set: .... **Date:** ....

Hazardous chemical or microorganism being used or made, or hazardous procedure or equipment	Nature of the hazard(s)	Source(s) of information	Control measures to reduce the risks	Emergency procedure

Checked by: .... **Date:** ....

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STUDENT SAFETY SHEETS

Index (Combined, all issues, 2009)

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STUDENT SAFETY SHEETS 1

Microorganisms

Source	Hazard	Comment
Samples from the environment	☣ BIOHAZARD	Air, water and soil samples could be used, but not samples from high-risk areas, eg, toilets or the floors of changing rooms. All environmental samples could be contaminated with **pathogens** (organisms which cause disease).
Samples from humans	☣ BIOHAZARD	'Finger dabs' could be used or hair from clean areas, eg, the scalp. Samples could, however, be contaminated with pathogens (see above).
Foods	☣ BIOHAZARD	Any uncooked animal product (eggs, meat, cheese etc) may be contaminated with bacteria, especially *Salmonella* and *Escherichia coli* (*E. coli*) from the gut, which can cause food poisoning. Take care to prevent cross contamination between cooked and uncooked foods. Thorough cooking will destroy bacteria.
Purchased cultures (ie, samples of microorganisms bought from suppliers)	☣ BIOHAZARD	Cultures bought from reputable suppliers (but not those from hospitals, etc) should be safe but may have become contaminated. *E. coli* is often studied in schools, but this is **not** the same strain of bacterium that causes food poisoning.

Typical control measures to reduce risk

- When culturing, if possible, grow bacteria and fungi on solids (agar) rather than liquids (broth) to avoid spills and aerosol formation. Choose culture media, eg, nutrient agar, that do not favour the growth of pathogens.
- Incubate at temperatures which do not encourage growth of pathogens (ie, not normally around 37 °C).
- Do **not** seal cultures completely *before* incubation (otherwise hazardous anaerobic bacteria are encouraged) but make sure they cannot be opened accidentally. *After* incubation, seal completely agar plates containing microbial samples taken from the environment or human skin before they are examined.
- Incubated cultures taken from the environment or humans must never be opened.
- Use sterile equipment and procedures (eg, by flaming loops and mouths of bottles, etc).
- Avoid draughts (from open windows and doors) which could contaminate cultures and cause spores from fungi (eg, mould) to spread.
- Work near Bunsen-burner flames so that the updraught helps to prevent contamination of cultures.
- After work is complete, treat surfaces using a suitable disinfectant, for a sufficient length of time.
- Dispose of all cultures (including mould on food) by sterilisation in an autoclave (pressure cooker).
- Always wash hands after handling cultures and before handling food.
- Wear a clean lab. coat or overall to protect cultures and food from microbes on the skin, clothing, etc.
- In cooking, ensure that food is heated to at least 70 °C for at least 2 minutes.
- Do not reheat cooked food; prepare, store and display cooked and uncooked foods separately.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could a food or a culture be, or become, contaminated? Could microorganisms or their spores escape?
- ***How serious would it be if something did go wrong?***
  Eg, Could material pathogenic to humans be released? Could food poisoning result?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered?

Emergency action

- **Spilt on the floor, bench, etc** For spills of cultures, place paper towels over the spill, pour disinfectant (eg, *Virkon*) on top and leave for at least 15 minutes. Bleach is usually suitable in the home.

STUDENT SAFETY SHEETS 2

Enzymes

includes **Amylase, Catalase, Cellulase, Diastase, Lipase, Proteases (eg, pepsin, trypsin), Urease**

Substance	Hazard	Comment
Enzymes Powders 'Biological' detergents contain enzymes.	☒ HARMFUL	All enzymes may be sensitisers (see below) and may produce allergic reactions. They can cause asthma and irritate the eyes, nose and skin.
Enzymes Concentrated solutions	☒ IRRITANT	All enzymes may be sensitisers (see below) and may produce allergic reactions. They can cause asthma and irritate the eyes, nose and skin.
Enzymes Dilute solutions Biological systems are, of course, rich sources of enzymes, eg, liver (catalase), saliva (amylase).	LOW HAZARD	The enzymes at these concentrations are unlikely to offer any significant risk.

Note: Some people are ***allergic*** to particular substances; their bodies' immune system reacts to these substances to an unusual extent. ***Asthma*** is one type of allergy which results in breathing difficulties. A ***sensitiser*** is a substance that may produce only a small or even no allergic reaction when humans are first exposed to it (sometimes over an extended period of time) but can produce a much more severe reaction on subsequent occasions, even when the body is exposed to much smaller amounts.

Typical control measures to reduce risk

- Use the lowest concentration/smallest amount possible.
- Reduce the risk of skin contact by wearing disposable gloves.
- Wear eye protection.
- **Avoid powdered enzymes escaping into the air; use a fume cupboard when handling enzyme powders.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could enzyme dust be breathed in?
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Wash out the mouth. Give a glass of water to drink. Do **not** make the casualty vomit. See a doctor.
• **Dust breathed in**	Remove the casualty to fresh air. See a doctor if breathing is difficult.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Wash off the skin with soap and plenty of water. Rinse contaminated clothing.
• **Spilt on the floor, bench, etc**	Scoop up powders (take care not to raise dust). Wipe up solution spills or any traces of powders with a damp cloth.

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STUDENT SAFETY SHEETS 3

Human body fluids and tissues

includes Cheek cells, blood, saliva, sweat & urine

Source	Hazard	Comment
Cheek cells	☣ BIOHAZARD	There is a very tiny risk of transmission of HIV or hepatitis virus but only if contact is made with samples other than your own. Sampling may be banned in some schools although this is very unlikely.
Blood	☣ BIOHAZARD	There is some risk of transmission of HIV or hepatitis virus if contact is made with blood other than your own. Taking blood samples is possible if stringent precautions are taken and may not be permitted in some schools. Never share hypodermic needles or become 'blood brothers'.
Saliva	LOW HAZARD	There is a negligible risk of transmission of HIV or hepatitis virus even if you come into contact with saliva other than your own. Kissing is rarely banned for reasons of hygiene!
Sweat	LOW HAZARD	There is a negligible risk of transmission of diseases even from contact with sweat other than your own, but this is no excuse for poor hygiene.
Urine	☣ BIOHAZARD	There is a very tiny risk of transmission of various diseases if you come into contact with urine other than your own, although urine is normally sterile. In investigations involving urine, take care when obtaining and transporting samples. Wash hands after using the toilet.

Typical control measures to reduce risk

- Only handle samples from your own body.
- After use, hygienically dispose of samples, disinfect by immersion for 30 minutes in a solution of sodium chlorate(I) (hypochlorite, eg, *Milton*) or *Virkon* (for 10 minutes) and rinse contaminated containers; treat benches for a sufficient length of time with a suitable disinfectant (*Virkon* is preferred) and wash hands. Any swabs, slides or other equipment contaminated with blood should be collected in a suitable container, then autoclaved. Use a 'sharps' container if necessary.
- Treat clinical thermometers, mouthpieces, etc in *Milton* for 30 minutes before and after use.
- In first aid, minimise contact with blood by wearing disposable surgical gloves or by asking the casualty to carry out her/his own treatment, eg, by applying pressure to a wound using a pad of cloth.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could somebody else come into contact with samples from your body, or vice versa?
  *If first-aid treatment was **not** applied, could the casualty's condition put his or her life at risk?*
- ***How serious would it be if something did go wrong?***
  Eg, Could HIV or hepatitis virus or other pathogens be transmitted?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered?

Emergency action

- **Spilt on the floor, bench, etc** For spills of most body fluid samples, place paper towels over the spill, pour disinfectant (eg, *Virkon*) on top and leave for at least 15 minutes. For blood, wear disposable gloves and use sodium chlorate(I) (hypochlorite, bleach) containing at least 10 000 ppm chlorine. Leave in contact for 15-30 minutes. Wash hands thoroughly.
- **Disposal of bloody tissues, etc** Avoid skin contact with tissues etc contaminated with blood. In school, place in a container for sanitary towels, etc. Then incinerate or use a clinical waste-collection service. At home, flush down the toilet or wrap carefully and place in the refuse.

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STUDENT SAFETY SHEETS 4

Food testing (1)

Substance	Hazard	Comment
Food	BIOHAZARD	Uncooked samples of food may be contaminated with microbes. (See *Student Safety Sheet 1, Microorganisms.*) Some people are allergic to some foods, especially peanuts.
Fehlings' solution Used to test for reducing sugars.	CORROSIVE	See *Student Safety Sheets 31* and *40*. Solution A contains slightly-acidic copper sulfate solution, but at concentrations which present only a LOW HAZARD. Solution B contains sodium hydroxide solution which is CORROSIVE. As the mixture has to be heated in a test tube, there is a risk of alkali spitting out.
Benedict's solution Used to test for reducing sugars.	LOW HAZARD	See *Student Safety Sheet 40.* Contains slightly-alkaline copper sulfate solution, but at concentrations which present only a LOW HAZARD. Some risk of spitting when heating test tubes.
Ethanol Used to test for fats (lipids).	HIGHLY FLAMMABLE	See *Student Safety Sheet 60.* If Bunsen burners are being used nearby for other food tests, there is a serious fire risk.
Iodine solution Used to test for starch.	LOW HAZARD	See *Student Safety Sheet 56.* Wear eye protection, though the solution in water is dilute and only presents a LOW HAZARD.
Biuret test Used to test for proteins.	IRRITANT	See *Student Safety Sheets 31* and *40.* Uses very dilute copper sulfate solution (LOW HAZARD) and sodium hydroxide solution which is IRRITANT (not CORROSIVE) if kept dilute (below 0.5 M).

Typical control measures to reduce risk

- Do not taste foods in laboratories; avoid using products containing peanuts etc if there is a known allergy.
- Wear eye protection and use the smallest possible amounts of chemicals.
- Use Benedict's solution rather than Fehling's solution and heat with a water bath.
- Do **not** use ethanol if there are naked flames nearby.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could chemicals spit out of a test tube?
  Might somebody using a Bunsen burner be unaware that a nearby person was using ethanol?
- ***How serious would it be if something did go wrong?***
  Could ethanol catch fire or alkali splash into the eye?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on skin or clothing**	Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Clothing catches fire**	Smother flames on clothing or skin with a fire blanket or other material. Cool any burnt skin with gently-running tap water for 10 minutes.
• **Other ethanol fires**	Allow fires in sinks, etc to burn out. Fires at the top of test tubes, beakers, etc should be smothered with a damp cloth or heat-proof mat if this can be done safely.
• **Spilt on floor, bench, etc**	For small amounts, use a damp cloth. Rinse well. For larger amounts, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise alkali with citric acid. Rinse with water.

Food testing (2)

Substance	Hazard	Comment
Millon's reagent Used to test for proteins.	VERY TOXIC / CORROSIVE	It contains a high concentration of a mercury compound and concentrated nitric acid (see *Student Safety Sheets* 21 and 44,). Cole's modification (Millon's reagent A) is somewhat less hazardous because it contains less-concentrated sulfuric acid, but it is still classed as VERY TOXIC and CORROSIVE. It also uses sodium nitrate(III) (nitrite) solution which is HARMFUL. Careful disposal is required. There is a risk of spitting when it is heated in a test tube.
Sakaguchi test Used to test for proteins.	TOXIC / CORROSIVE HIGHLY FLAMMABLE / HARMFUL	The test involves mixing three solutions which contain sodium hydroxide solution (CORROSIVE), napthalen-1-ol (HARMFUL) dissolved in ethanol (HIGHLY FLAMMABLE) and sodium chlorate(I) (hypochlorite) (CORROSIVE). See relevant *Student Safety Sheets.* Despite these hazards, it is safer to use than either form of Millon's reagent because it does not need to be heated and only a few drops are required. The biuret test is safer still (see *Sheet* 4).
DCPIP Used to test for Vitamin C.	LOW HAZARD	See *Student Safety Sheet 70, Dyes and indicators.* (Also known as PIDCP.)
Saliva Used to break down starch.	LOW HAZARD	See *Student Safety Sheet 3, Human body fluids and tissues.* Negligible risk.
Clinistix Used to test for glucose.	LOW HAZARD	The tip of the stick contains a minute amount of a known carcinogen and should not be touched. The sticks should be stored and disposed of safely. It is normally used for testing urine.
Albustix Used to test for proteins.	LOW HAZARD	This will not detect all proteins. It is normally used for testing urine.

Typical control measures to reduce risk

- Wear eye protection and use the smallest possible amounts of chemicals.
- Use the least-hazardous substance that achieves the required effect.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could chemicals spit out of the test tube?
- ***How serious would it be if something did go wrong?***
  Could ethanol (in the Sakaguchi test) catch fire, or acid splash into the eye?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

- **In the eye** Flood the eye with gently-running tap water for 10 minutes. See a doctor.
- **Swallowed** Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
- **Spilt on skin or clothing** Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
- **Clothing catches fire** Push the casualty to the floor, roll the body or smother flames on clothing or skin with a fire blanket or other material. Cool any burnt skin with gently-running tap water for 10 minutes.
- **Other ethanol fires** Allow fires in sinks, etc to burn out. Fires at the top of test tubes, beakers, etc should be smothered with a damp cloth or heat-proof mat if this can be done safely.
- **Spilt on the floor, bench, etc** Wipe up small amounts with a damp cloth. Rinse well. For larger amounts, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise alkali with citric acid or acid with sodium carbonate. Rinse with plenty of water.

STUDENT SAFETY SHEETS 10

Electricity

Situation	Hazard	Comment
Electric power distribution 230 V ac and above at high currents (over 5 mA).	ELECTRIC SHOCK / BURN	*In non-school contexts*: over-head power lines and local sub-stations could cause accidents if children behave foolishly.
Home and school Above 28 V ac or 40 V dc and at currents over 5 mA. This includes the 230 V ac mains supply.	ELECTRIC SHOCK / BURN	*In school science*: problems may arise from terminals of high voltage (high tension, HT) supplies or low-voltage units with an HT outlet (as some supply 150 mA); also in activities involving electrophoresis, model transformers or conductivity of molten glass. *In non-school contexts*: problems arise due to poor insulation (damaged wiring and plugs), incorrect wiring, over-loaded circuits, poor earthing or vandalism.
School science investigations Less than 28 V ac or 40 V dc and at currents over 5 mA. This includes almost all work with batteries in school or elsewhere.	LOW ELECTRICAL HAZARD TOXIC / CORROSIVE	Most school circuit work, including electrolysis, is in this category (although problems could arise if currents over 10 A were used). Some cells, batteries and accumulators contain TOXIC or CORROSIVE materials.
Everywhere: eg, static electricity Any voltages at very low currents (well below 5 mA)	LOW HAZARD	Examples include the van de Graaff generator (but **not** induction coils which may give over 5 mA). Electronic equipment nearby may be damaged by static discharges or electromagnetic fields.

Typical control measures to reduce risk

- Use the lowest voltage possible (and, for electrolysis, the lowest current and concentration that gives good results).
- Avoid exposed conductors which are live above 28 V.
- Avoid the possibility of water coming into contact with conductors which are live above 28 V.
- Check that primary and secondary insulation (ie, both layers of plastic coating) are in good condition.
- Avoid over-loaded circuits, too many plugs in one socket, etc.
- Check that plugs are correctly wired with appropriate fuses.
- Ensure good earth connections where necessary.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Accidentally touching a live component through poor design or poor maintenance.
- ***How serious would it be if something did go wrong?***
  Eg, Could a current flow through the heart? How large a voltage and/or current?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered?

Emergency action

- **Electric shock**

Take care for your own safety.

Break contact by switching off or removing the plug. If this is not possible, use a wooden broom handle or wear rubber gloves to pull the casualty clear. See a doctor.

If the casualty is unconscious, check that airways are clear and that the casualty is breathing and has a pulse. If so, place the casualty in the 'recovery position'. If a pulse is found but the casualty is not breathing, artificial ventilation is necessary. If no pulse is found and the casualty is not breathing, cardio-pulmonary resuscitation is necessary.

Radioactive materials

Substance	Hazard	Comment
Alpha sources (α radiation) Low-activity α sources are used in domestic smoke alarms.	☢ IONISING RADIATION	Produce heavy ionisation (see *Additional Information*, below) but range is less than 1 mm in living tissue. Little problem if source is kept outside body.
Beta sources (β radiation) All samples of potassium and its compounds (including granite rocks, clays, etc) contain very small amounts of a natural β emitter.	☢ IONISING RADIATION	Produce medium ionisation (see *Additional Information*, below) but the range is a few centimetres in living tissue. There is little problem if source is kept away from the body.
Gamma sources (γ radiation) Very active γ sources are used in hospitals for killing cancer cells. Domestic smoke alarms emit a little γ radiation.	☢ IONISING RADIATION	Produce little ionisation (see *Additional Information*, below) but the range is long in living tissue, some passing right through the body. In schools, use a weak source and keep well away from the body.

Additional information:

- When (ionising) radiation is absorbed by living tissue, mostly it results in a few extra hydrogen ions and hydroxide ions in the cytoplasm of cells. These rapidly recombine to form water.
- Some radiation is absorbed by more-complex molecules and the ions from these can result in the death of the cell.
- Low levels of ionising radiation have little noticeable effect because biological organisms are continually replacing cells which die for other reasons anyway.
- High doses of radiation can result in skin burns (like sunburn) or radiation sickness (where so many cells have been killed that an organ ceases to function properly).
- Ionising radiation can also affect DNA in cells and change the genetic code. In reproductive organs, this could cause abnormal offspring but has never been confirmed in humans.
- Modified DNA may allow cells to reproduce out of control and form a cancer.

Typical control measures to reduce risk

- Use the lowest-activity source possible (only low-level sources are permitted in schools).
- Keep as far away from the source as possible (For school sources, use a handling tool which keeps the source at least 10 cm from the hand. Observers of demonstrations should generally keep at least 2 m away.).
- Have a clear set of local rules, including "Sources must not be handled by under-16s".
- When radioactive solids, liquids or gases (open sources) are in use, prevent contamination of people (by use of lab coats and disposable plastic gloves), of benches (by use of trays and sheets of absorbing paper) and apparatus (by handling equipment with disposable tissues).

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Source is dropped, spilt or stolen or somebody moves too close to the source.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered?

Emergency action

• **Sealed source dropped**	Do not look directly at a source; use a mirror to examine a source for damage. Check the area for radioactivity where a source was dropped.
• **Spilt on the skin or swallowed**	Wash the affected area thoroughly and check for radioactivity. If swallowed, go to a hospital specialising in radiation incidents.
• **Open source spilt on the floor, bench, etc**	Wipe up small amounts with damp tissues. Wipe the area until count rate is less than 50% above background. Place tissues in a plastic bag and dispose of it in solid waste.

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STUDENT SAFETY SHEETS 12

Electromagnetic radiation

Type of radiation	Hazard	Comment
Radio waves Wavelength 10^3 m.	LOW HAZARD	-
Microwaves Wavelength 10^{-2} m.	⚠ NON-IONISING RADIATION	They are strong sources produce local heating. Microwave ovens should be operated and maintained according to instructions, so that microwaves cannot leak out. Using mobile phones is safe if the power is less than 100 W m^{-2}.
Infra red Wavelength 10^{-5} m.	⚠ NON-IONISING RADIATION	It can produce skin burns and strong sources (eg, furnaces for melting iron) may damage the cornea of the eye. It may ignite combustible materials.
Visible Wavelength 0.5 x 10^{-6} m.	⚠ NON-IONISING RADIATION ⚠ LASER RADIATION	Intense sources (eg, from the Sun and narrow beams from class 3 & 4 lasers) may damage the retina. Class 1 lasers (eg, in laser printers) are totally enclosed. Class 2 lasers are low power (less than 1 mW) and safe unless the 'blink response' is over-ridden or ignored. Laser pointers are class 3 lasers (typical power 3 mW) and are more dangerous, especially if misused. Direct observation of eclipses of the Sun often results in blindness.
Ultra violet Wavelength 10^{-8} m. UV-A, long-wave UV; UV-B, short-wave UV	⚠ NON-IONISING RADIATION	It can cause sunburn. There is a risk of skin cancer. Do not sunbathe without adequate protection. UV-A is used in sun beds. UV-B can damage the eyes; it is produced in electric-arc or oxy-acetylene welding. Wear snow goggles when skiing.
X-rays Wavelength 10^{-10} m.	⚠ IONISING RADIATION	X-rays are produced in low-pressure systems by sparks and discharges at more than 6 kV. Large doses cause burns and may induce cancer.
Gamma (γ) rays Wavelength 10^{-12} m.	⚠ IONISING RADIATION	See *Student Safety Sheet 11, Radioactive materials.*

Additional information: There is no evidence that electric and magnetic fields at ordinary intensities affect the human body. Microwaves and infra-red radiation have both been used medically to give relief from pain. X-rays are used in medicine for diagnosis and treatment (but should be avoided during pregnancy).

Typical control measures to reduce risk

- X-ray sets are permitted in schools only where there are suitably-qualified staff.
- Ultra-violet lamps must be screened or personal protective equipment used (also for welding).
- Lasers for use in schools must be class 1 or class 2, when the rule is "Do not stare down the beam".
- Use sun lotions with a suitable protection factor and do not sunbathe without adequate protection.
- Never look directly at the Sun (even during an eclipse) or through a lens, filter or pin hole.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered?

Emergency action

• **Radiation burns to the skin**	Treat as for a heat burn, ie, cool burnt skin under gently-running tap water for 10 minutes. See a doctor if more than an area the size of a small coin is affected.
• **Suspected eye damage**	Cover and see a doctor.

Hydrochloric acid

also applies to **Hydrogen chloride gas**

Substance	Hazard	Comment
Hydrogen chloride Gas	TOXIC CORROSIVE	It is toxic if breathed in. It causes severe burns and irritates the lungs. For a 15-minute exposure, the concentration in the atmosphere should not exceed 8 mg m^{-3}.
Concentrated hydrochloric acid *(If 6.5 M or more)*	CORROSIVE	It causes burns. The vapour irritates the lungs.
Moderately-concentrated hydrochloric acid *(If less than 6.5 M but 2 M or more)*	IRRITANT	It may irritate the eyes and skin.
Dilute hydrochloric acid *(If less than 2 M)*	LOW HAZARD	This includes stomach acid. Dilute acid may still cause harm in the eyes or in a cut.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest volume possible.
- Wear eye protection for all but the most-dilute solutions.
- Wear protective gloves if anything more than tiny amounts of concentrated acid are handled.
- **Avoid breathing the gas or fumes from concentrated solutions, eg, by use of a fume cupboard.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Hazardous products (such as chlorine) produced as a result of a reaction with the acid or choking fumes produced if concentrated acid is over-heated.
- ***How serious would it be if something did go wrong?***
  NB There are occasional reports of pupils being taken to hospital as a result of breathing in chlorine.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Vapour breathed in**	Remove to fresh air. Call a doctor if breathing is difficult.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Spilt on the floor, bench, etc**	**For release of gas, consider the need to evacuate the laboratory and open all windows.** For large spills, and especially for (moderately) concentrated acid, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.

STUDENT SAFETY SHEETS 21

Nitric(V) acid

Substance	Hazard	Comment
Concentrated nitric(V) acid	CORROSIVE OXIDISING	It causes severe burns; skin is stained yellow and then peels. For a 15-minute exposure, the vapour concentration in the atmosphere should not exceed 2.6 mg m^{-3}. If over 11 M, the acid may cause fire in contact with combustible materials.
Moderately-concentrated nitric(V) acid *(If 0.5 M or more)*	CORROSIVE	It causes severe burns.
Moderately-dilute nitric(V) acid *(If less than 0.5 M but 0.1 M or more)*	IRRITANT	It is irritating to the eyes and skin.
Dilute nitric(V) acid *(If less than 0.1 M)*	LOW HAZARD	It may still cause harm in the eyes or in a cut.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest volume possible.
- Wear eye protection, including when making or disposing of solutions.
- Wear protective gloves if concentrated acid is handled on anything larger than a test-tube scale.
- Ensure good ventilation if oxides of nitrogen could be formed.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Hazardous products are formed in reactions with the acid (such as oxides of nitrogen) or corrosive fumes are produced if concentrated acid is over-heated.
- ***How serious would it be if something did go wrong?***
  Eg, Peeling skin, from burns caused by concentrated acid, may be very painful.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
Fumes breathed in	Remove the casualty to fresh air. Keep him/her warm. If more than a ‘sniff’ is inhaled, see a doctor even if no symptoms are apparent.
Swallowed	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Spilt on the skin or clothing	Quickly use a dry cloth or paper towel to wipe as much liquid off the skin as possible. Then drench with plenty of water. If a large area is affected or blistering occurs, see a doctor. Remove contaminated clothing and rinse it well.
Spilt on the floor, bench, etc	Wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated acid, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water.

STUDENT SAFETY SHEETS 22

Sulfuric(VI) acid

Substance	Hazard	Comment
Concentrated sulfuric(VI) acid	CORROSIVE	It causes severe burns. It reacts violently, becoming very hot, when mixed with water. For a 15-minute exposure, the vapour concentration in the atmosphere should not exceed 3.0 mg m^{-3}.
Moderately-concentrated sulfuric(VI) acid *(If 1.5 M or more)* Includes acid used in car batteries.	CORROSIVE	It causes severe burns.
Moderately-dilute sulfuric(VI) acid *(If less than 1.5 M but 0.5 M or more)*	IRRITANT	It is irritating to the eyes and skin.
Dilute sulfuric(VI) acid *(If less than 0.5 M)*	LOW HAZARD	It may still cause harm in the eyes or in a cut.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest volume possible.
- Wear eye protection, including when making or disposing of solutions.
- Wear protective gloves if concentrated acid is handled on anything larger than a test-tube scale.
- **Add the concentrated acid slowly to cold water (or preferably ice) when diluting, never the reverse; stir frequently to ensure good mixing.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Hazardous products are formed in reactions with the acid or corrosive fumes are produced if concentrated acid is over-heated.
- ***How serious would it be if something did go wrong?***
  Eg, Skin and eyes can be seriously burned if not treated quickly.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Especially with concentrated acid, quickly use a *dry* cloth or paper towel to wipe as much liquid as possible off the skin. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Spilt on the floor, bench, etc**	Wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated acid, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water.

Ethanoic (acetic) acid

also applies to **Methanoic (formic) acid**

Substance	Hazard	Comment
Ethanoic acid (acetic acid) Pure liquid, 'glacial' Also methanoic (formic) acid.	CORROSIVE FLAMMABLE	It causes severe burns and irritates the lungs. For a 15-minute exposure, the concentration of the vapour in the atmosphere should not exceed 37 mg m^{-3} (28.8 mg m^{-3} for methanoic acid). Some descalers for kettles, irons etc use methanoic acid.
Concentrated ethanoic (acetic) acid Solution in water *(If 4 M or more)*	CORROSIVE	It causes burns. Also methanoic (formic) acid.
Moderately-concentrated ethanoic (acetic) acid *(If less than 4 M but 1.7 M or more)*	IRRITANT	It is irritating to the eyes and skin. Also methanoic (formic) acid, including ant venom.
Dilute ethanoic (acetic) acid *(If less than 1.7 M)*	LOW HAZARD	It may still cause harm in the eyes or in a cut. This includes vinegar.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest volume possible.
- Wear eye protection for all but the most-dilute solutions.
- Wear protective gloves if anything more than tiny amounts of concentrated acid are handled.
- Avoid breathing gas or fumes from concentrated solutions, eg, by use of a fume cupboard.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Choking fumes if concentrated acid is over-heated.
- ***How serious would it be if something did go wrong?***
  NB We put vinegar on chips!
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently running tap water for 10 minutes. See a doctor.
• **Vapour breathed in**	Remove to fresh air. Call a doctor if breathing is difficult.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Spilt on the floor, bench, etc**	Wipe up small amounts with a damp cloth and rinse it well. For large spills, and especially for (moderately) concentrated acid, cover with mineral absorbent (eg, cat litter) and scoop into bucket. Neutralise with sodium carbonate. Rinse with plenty of water.

Phosphoric(V) acid

also known as **Orthophosphoric acid**

Substance	Hazard	Comment
Concentrated phosphoric(V) acid	CORROSIVE	It causes burns. It reacts violently, becoming very hot, when mixed with water. It decomposes if heated strongly, forming toxic oxides of phosphorus.
Moderately-concentrated phosphoric(V) acid *(If 2.5 M or more)*	CORROSIVE	It causes burns. This includes phosphoric acid used in most descaling and rust treatments.
Moderately dilute phosphoric(V) acid *(If less than 2.5 M but 0.5 M or more)*	IRRITANT	It is irritating to the eyes and skin.
Dilute phosphoric(V) acid *(If less than 0.5 M)*	LOW HAZARD	It may still cause harm in the eyes or in a cut. This includes acid used in cola drinks, etc. Over long periods of time, the acid may attack teeth.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest volume possible.
- Wear eye protection, including when making or disposing of solutions.
- Wear protective gloves if concentrated acid is handled on anything larger than a test-tube scale.
- **Add the concentrated acid slowly to cold water when diluting, never the reverse; stir frequently to ensure good mixing.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Hazardous products are formed in reactions with the acid or corrosive fumes are produced if concentrated acid is over-heated.
- ***How serious would it be if something did go wrong?***
  Eg, The skin and eyes can be seriously burned if not treated quickly.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Especially with concentrated acid, quickly use a dry cloth or paper towel to wipe as much liquid as possible off the skin. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Spilt on the floor, bench, etc**	Wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated acid, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water.

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STUDENT SAFETY SHEETS 25

Citric, Oxalic & Tartaric acids

2-hydroxypropane-1,2,3-tricarboxylic acid,

Ethanedioic acid & 2,3-dihydroxybutanedioic acid

Substance	Hazard	Comment
Citric acid Solid and concentrated solutions *(If 1.0 M or more)*	☒ IRRITANT	(2-hydroxypropane-1,2,3-tricarboxylic acid**)** It is irritating to eyes. It is an approved food additive, E330. Concentrated lemon juice may contain citric acid up to 1.7 M.
Dilute citric acid *(If less than 1.0 M)*	LOW HAZARD	Even dilute solutions will cause discomfort in the eye. It is found in citrus fruits, eg, lemons, oranges, grapefruit. Lemons contain citric acid up to about 0.25 M.
Oxalic acid (ethanedioic acid) Solid and most solutions *(If 0.5 M or more)*	☒ HARMFUL	It is harmful in contact with the skin and if swallowed. It is quite close to the limit at which it would be classed as TOXIC rather than HARMFUL. It removes calcium ions from the blood, forming insoluble calcium oxalate; this can block kidneys. Soluble salts of oxalic acid (eg, sodium, potassium) are as hazardous as the acid. It is found in rhubarb, especially in the leaves and in unripe leaf stalks (ie, the part which is eaten). Cases of poisoning have been reported, although very rarely fatal. The toxic effects of rhubarb may be due to other substances.
Dilute oxalic acid *(If less than 0.5 M)*	LOW HAZARD	Even dilute solutions will cause discomfort in the eye.
Tartaric acid (2,3-dihydroxy-butanedioic acid) Solid and concentrated solutions *(If 1.4 M or more)*	☒ IRRITANT	It is used in baking powder and is found in many food products. It is an approved food additive, E334.
Dilute tartaric acid *(If less than 1.4 M)*	LOW HAZARD	Even dilute solutions will cause discomfort in the eye.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Wear eye protection for all but dilute solutions.
- Avoid the possibility of swallowing oxalic acid or its salts, eg, by using a safety pipette filler.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Specks of solid acid transferred into the eye, by rubbing with a contaminated finger.
- ***How serious would it be if something did go wrong?***
  NB We do eat rhubarb!
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should eye protection be worn?

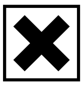
Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Then drench the skin with plenty of water.
• **Spilt on the floor, bench, etc**	Wipe up small amounts with a damp cloth and rinse it well. For large spills, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with sodium carbonate. Rinse with plenty of water.

STUDENT SAFETY SHEETS 30

Ammonia (gas & solution)

also applies to **Ammonium hydroxide**

Substance	Hazard	Comment
Ammonia (gas)	 TOXIC	It is irritating to the eyes and lungs; breathing it can lead to severe poisoning. However, the human nose can detect ammonia at well below danger levels. For a 15-minute exposure, the concentration in the atmosphere should not exceed 25 mg m^{-3}. (It is also DANGEROUS FOR THE ENVIRONMENT because it is very toxic to aquatic organisms.)
Concentrated ammonia solution *(If 6 M or more)*	 CORROSIVE	'880' ammonia, (ammonium hydroxide solution). It causes burns; it is dangerous to the eyes (goggles should be worn). It causes severe internal damage if swallowed. Ammonia gas will be present and the **pressure of gas builds up on hot days.** (It is also DANGEROUS FOR THE ENVIRONMENT because it is very toxic to aquatic organisms.)
Moderately-concentrated ammonia solution *(If less than 6 M but 3 M or more)*	 IRRITANT	(Ammonium hydroxide solution). This includes 'household' ammonia. It is irritating to the eyes and skin. Its odour can cause distress.
Dilute ammonia solution *(If less than 3 M)*	LOW HAZARD	(Dilute ammonium hydroxide solution) It may still cause harm in eyes or in a cut.

Typical control measures to reduce risk

- Use the lowest concentration and smallest volume possible.
- **Wear suitable eye protection**, including when making or disposing of solutions.
- Use a fume cupboard for all but test-tube amounts of the gas and more-concentrated solutions (including opening bottles); ensure good laboratory ventilation.
- If smelling the gas, follow the safe technique for sniffing gases: use your hand to waft the gas towards your nose.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
- *Eg, Solution spurting out of test tubes when being heated; release of ammonia gas as a product of a chemical reaction; possibility of the ammonia gas concentration reaching dangerous levels.*
- ***How serious would it be if something did go wrong?***
  NB Alkali in the eye causes more damage than acid of equivalent concentration.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 20 minutes (for alkalis). See a doctor. If it is necessary to go to hospital, continue washing the eye during the journey in an ambulance.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if breathing is difficult.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Spilt on the floor, bench, etc**	**Consider the need to evacuate the laboratory and open windows** if large amounts are spilt and especially for (moderately) concentrated solutions. Cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with citric acid. Rinse with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.

Sodium hydroxide

also applies to Soda lime & Potassium hydroxide

Substance	Hazard	Comment
Sodium hydroxide Solid Also potassium hydroxide (solid)	CORROSIVE	(Caustic soda and potash) Also soda lime. It causes severe burns; it is particularly dangerous to the eyes. It gives out heat when added to water. It is used in the home for clearing drains.
Sodium or potassium hydroxide solution *(If 0.5 M or more)*	CORROSIVE	It causes severe burns; it is particularly dangerous to the eyes. Fehling's solution contains sodium hydroxide of this concentration. It is used in the home as an oven cleaner.
Dilute sodium or potassium hydroxide solution *(If less than 0.5 M but 0.05 M or more)*	IRRITANT	It is irritating to the eyes and skin.
Very dilute sodium or potassium hydroxide solution *(If less than 0.05 M)*	LOW HAZARD	It may still cause harm in the eyes or in a cut.

Typical control measures to reduce risk

- Use the lowest concentration possible; avoid the solid if possible.
- Use the smallest amount possible.
- **Wear eye protection**, including when making or disposing of solutions. Goggles (or a face shield) rather than safety spectacles will be necessary if the chemical is classed as CORROSIVE at the concentration used.
- Wear protective gloves if the concentrated solution is handled in more than tiny amounts.
- If possible, use a safer alternative, eg, sodium carbonate when making salts or Benedict's solution rather than Fehling's solution for food tests.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, The solution spurting out of a test tube when being heated.
- ***How serious would it be if something did go wrong?***
  NB Alkali in the eye causes more damage than acid of equivalent concentration.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for at least 20 minutes. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance.
Swallowed	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Spilt on the skin or clothing	Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
Spilt on the floor, bench, etc	Wipe up small amounts with a damp cloth and rinse it well. For larger amounts, and especially for (moderately) concentrated solutions, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Neutralise with citric acid. Rinse with plenty of water.

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STUDENT SAFETY SHEETS 32

Calcium hydroxide & oxide

including Slaked lime, Quick lime & Limewater

Substance	Hazard	Comment
Calcium oxide Solid **Quick lime** (Old samples of calcium oxide are mostly calcium hydroxide.)	CORROSIVE	It causes burns. There is a risk of serious damage to the eyes. It is irritating to the skin, lungs, etc. It reacts violently with water, becoming very hot - dust particles may shoot out. For a 15-minute exposure, the concentration of the powder in the atmosphere should not exceed 6 mg m^{-3}.
Calcium hydroxide Solid Slaked lime, garden lime	(IRRITANT)	It is not officially classified, but there is a risk of serious damage to the eyes. It is irritating to the skin, lungs, etc. For a 15-minute exposure, the concentration of the powder in the atmosphere should not exceed 15 mg m^{-3}.
Calcium hydroxide Solution Limewater *(Limewater is a saturated solution of calcium hydroxide, less than 0.02 M.)*	(IRRITANT)	Even a saturated solution of calcium hydroxide is so dilute that it is not classed as IRRITANT. However, limewater is usually made in schools by adding excess solid calcium hydroxide (or oxide) to water. Undissolved solid will remain and that is irritating to the eyes and skin (but any solid present might well be calcium carbonate, LOW HAZARD).

Typical control measures to reduce risk

- Wear eye protection when handling solids.
- Eye protection is advisable when using limewater, especially if blowing into it.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solid particles spitting when adding water, dust blowing around or liquid splashing into the eye when blowing into limewater.
- ***How serious would it be if something did go wrong?***
  NB Alkali in the eye causes more damage than acid of an equivalent concentration.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Solids: flood the eye with gently-running tap water for at least 20 minutes. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance. Limewater is unlikely to cause serious problems; flood the eye with gently-running tap water for at least 10 minutes. See a doctor if there are any concerns.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. Limewater is unlikely to cause serious problems. Wash out the mouth. See a doctor if there are any concerns.
• **Spilt on the skin or clothing**	Brush off the solid. Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. For limewater, wash with water.
• **Spilt on the floor, bench, etc**	Wipe up limewater or small amounts of solid with a damp cloth and rinse it well. For larger amounts of solid, scoop into a bucket, add water to the area followed by mineral absorbent (eg, cat litter).

Sodium & Calcium carbonates

including **Hydrogencarbonates (bicarbonates)** *&* **Potassium /Magnesium salts**

Substance	Hazard	Comment
Sodium & potassium carbonate Hydrated or anhydrous solid	☒ IRRITANT	They are irritating to the eyes but the anhydrous solid presents a bigger risk because it is finely powdered, whereas the hydrate is crystalline (usually large crystals). Soda ash is an impure (industrial) form. Hydrated sodium carbonate is used as washing soda. They are approved food additives, E500 & E501.
Sodium & potassium carbonate Concentrated solution *(If 1.8 M or more)*	☒ IRRITANT	This is almost a saturated solution.
Sodium & potassium carbonate Dilute solution *(If less than 1.8 M)*	LOW HAZARD	They are used as a dilute solution in bath salts.
Sodium & potassium hydrogencarbonate (bicarbonate) Solid and solution Also **Sodium sesquicarbonate**	LOW HAZARD	They liberate carbon dioxide on gentle heating (or with acids). Sodium hydrogencarbonate is an approved food additive, E500, and is used as baking soda. 'Bicarb' or 'bicarbonate of soda' are old-fashioned names. Bath salts contain sodium sesquicarbonate, (sodium carbonate hydrogencarbonate), $Na_2CO_3.NaHCO_3.H_2O$.
Calcium & magnesium carbonate Solid	LOW HAZARD	Calcium carbonate occurs naturally as marble, chalk and limestone. It decomposes if heated above 800 °C and gives carbon dioxide with acids (unless the calcium salt is insoluble). It is an approved food additive, E170. Blackboard chalk may be calcium carbonate but is more likely to be calcium sulfate. Magnesium carbonate also occurs naturally. It decomposes more easily and is also an approved food additive, E504.
Calcium & magnesium hydrogencarbonate (bicarbonate) Solution	LOW HAZARD	The solid does not exist. The solution is the cause of temporary hardness of water. On warming, calcium (or magnesium) carbonate ('limescale', 'fur') is deposited. The solution reacts with soap to produce insoluble calcium (or magnesium) salts ('scum').

Typical control measures to reduce risk

- Wear eye protection when handling irritant solids and avoid raising dust.
- Avoid contact with acids, especially in sealed containers, because large volumes of carbon dioxide will be formed.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Specks of solid transferred into the eye, by rubbing with a contaminated finger.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should eye protection be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
• **Spilt on the floor, bench, etc**	Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.

Sodium & Potassium salts

Substance	Hazard	Comment
Sodium chloride, bromide and iodide Also potassium chloride, bromide and iodide	LOW HAZARD	Although regarded as low hazard, there have been cases of people killed through consuming a very large amount of sodium chloride. Even at 'normal' levels it can cause high blood pressure and hence heart disease. Adults should not eat more than 6 g per day, children even less. Potassium chloride is an approved food additive, E508, sometimes used as a 'low-salt' substitute.
Sodium sulfate(VI) Also potassium sulfate(VI)	LOW HAZARD	Hydrated sodium sulfate(VI), $Na_2SO_4.10H_2O$ is known as Glauber's salt. Sodium sulfate(VI) is an approved food additive, E514, as is the potassium salt, E515.
Sodium hydrogensulfate(VI) (bisulfate) Solid and concentrated solution (*If 0.8 M or more*)	CORROSIVE	It is strongly acidic because of acidic hydrogen in $NaHSO_4$. It causes burns and is irritating to the respiratory system. It is used in some toilet cleaners.
Sodium hydrogensulfate(VI) (bisulfate) Fairly dilute solution (*If 0.3 M or more but less than 0.8 M*)	IRRITANT	It is strongly acidic because of acidic hydrogen in $NaHSO_4$.
Sodium hydrogensulfate(VI) (bisulfate) Solution (*If less than 0.3 M*)	LOW HAZARD	It is strongly acidic because of acidic hydrogen in $NaHSO_4$.
Sodium nitrate(V) Also potassium nitrate(V)	OXIDISING	Only the solid is considered hazardous although the solution does have oxidising properties. Sodium nitrate(V) is an approved food additive, E251, as is the potassium salt, E252.
Sodium or **potassium carbonate** and **hydrogencarbonate**		See *Student Safety Sheet 33.*
Sodium chlorate(I) (hypochlorite)		See *Student Safety Sheet 41.*
Sodium or **potassium chromate(VI)** or **dichromate(VI)**		See *Student Safety Sheet 47.*
Sodium or **potassium manganate(VII) (permanganate)**		See *Student Safety Sheet 48.*
Sodium or potassium oxalate (ethanedioate)		See *Student Safety Sheet 25*.

Typical control measures to reduce risk

- Wear eye protection when handling hazardous solids and solutions.
- Avoid raising dust.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Specks of solid transferred into the eye, by rubbing with a contaminated finger.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should eye protection be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
• **Spilt on the floor, bench, etc**	Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.

STUDENT SAFETY SHEETS 35

Sodium sulfites, thiosulfate & persulfate

including metabisulfite & Potassium salts

Substance	Hazard	Comment
Sodium & potassium sulfite [sulfate(IV)] Solid and concentrated solution (*If 0.25 M or more*)	HARMFUL	They are harmful if swallowed. There is a risk of serious damage to the eyes. With acids, produce sulfur dioxide (SO_2) (a TOXIC & CORROSIVE gas, see *Sheet 52*); do not inhale. Smell of SO_2 due to acidification by CO_2 in air. An approved food additive, E221, as a preservative.
Sodium & potassium sulfite [sulfate(IV)] Dilute solution (*If less than 0.25 M*)	LOW HAZARD	They smell of sulfur dioxide due to acidification by carbon dioxide in the air; do not inhale.
Sodium & potassium hydrogensulfite [hydrogensulfate(IV)]	LOW HAZARD	The pure solid $NaHSO_3$ does not exist. Products sold as bisulfite contain metabisulfite. Sodium and potassium hydrogensulfites are approved food additives, E222 and E228, as preservatives.
Sodium & potassium metabisulfite [disulfate(IV)] Solid and most solutions (*If 0.25 M or more*)	HARMFUL	They are harmful if swallowed. There is a risk of serious damage to the eyes. With acids, they produce sulfur dioxide (SO_2) (TOXIC & CORROSIVE gas, see *Sheet 52*); do not inhale. They smell of SO_2 due to acidification by CO_2 in air. Sodium & potassium metabisulfites are approved food additives, E223 and E224, as preservatives.
Sodium & potassium metabisulfite [disulfate(IV)] Dilute solutions (*If less than 0.25 M*)	LOW HAZARD	Although sodium metabisulfite solid is $Na_2S_2O_5$, it behaves as sodium hydrogensulfite, $NaHSO_3$, in solution.
Sodium & potassium thiosulfate	LOW HAZARD	They produce sulfur (see *Sheet 82*) & sulfur dioxide (TOXIC & CORROSIVE gas, see *Sheet 52*) with acids, including carbon dioxide. Carbon dioxide may cause solutions to go cloudy.
Sodium & potassium persulfate [peroxodisulfate(VI)] Solid and solutions (*If 0.04 M or more*)	OXIDISING / HARMFUL	$Na_2S_2O_8$ is used as an oxidising agent, eg, for bleaching hair, etching printed-circuit boards and to initiate polymerisation reactions. (If less than 0.04 M, the solutions are LOW HAZARD.)
Sodium sulfate(VI) and **hydrogensulfate(VI)**		See *Student Safety Sheet 34.*

Typical control measures to reduce risk

- Use the smallest quantity or concentration possible.
- Wear eye protection when handling hazardous solids and solutions.
- Take care not to inhale sulfur dioxide; asthmatics should be especially careful.
- Avoid exposure to sulfur dioxide, eg, by using a fume cupboard.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Accidental inhalation of sulfur dioxide when opening a bottle or dissolving a solid in water.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should eye protection be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
• **Spilt on the floor, bench, etc**	Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.

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STUDENT SAFETY SHEETS 36

Magnesium & Calcium salts

Substance	Hazard	Comment
Magnesium chloride	LOW HAZARD	It is an approved food additive, E511.
Calcium chloride Anhydrous and hydrated solid and concentrated solution (*If 1 M or more*)	☒ IRRITANT	It is an approved food additive, E509. Anhydrous calcium chloride is often used as a drying agent.
Calcium chloride Dilute solution (*If less than 1 M*)	LOW HAZARD	-
Magnesium sulfate(VI)	LOW HAZARD	Hydrated magnesium sulfate, known as Epsom salts, is used as a medicine (a purgative). It is a cause of permanently hard water.
Calcium sulfate(VI)	LOW HAZARD	It is used as Plaster of Paris, for setting broken bones: $CaSO_4.½H_2O$ absorbs water, becomes hot and expands slightly forming $CaSO_4.2H_2O$ (gypsum). It is not safe to attempt to make a cast of the whole hand or encase any other part of the body. Unlike magnesium sulfate(VI), calcium sulfate(VI) is only sparingly soluble. It is commonly used as blackboard chalk. It is a cause of permanently-hard water. It is an approved food additive, E516.
Magnesium nitrate(V)	🔥 OXIDISING	Only the solid is considered hazardous, although the solution does have oxidising properties.
Calcium nitrate(V) Solid	🔥 ☒ OXIDISING / IRRITANT	-
Calcium nitrate(V) Concentrated solution (*If 0.8 M or more*)	☒ IRRITANT	The solution has oxidising properties.
Calcium nitrate(V) Dilute solution (*If less than 0.8 M*)	LOW HAZARD	The solution has oxidising properties.
Calcium (and **magnesium) carbonate** and **hydrogencarbonate**		See *Student Safety Sheet 33.*
Calcium oxalate (ethanedioate)		See *Student Safety Sheet 25.*

Typical control measures to reduce risk

- Wear eye protection when handling hazardous solids and solutions.
- Avoid raising dust.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Specks of solid transferred into the eye, by rubbing with a contaminated finger.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should eye protection be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
• **Spilt on the floor, bench, etc**	Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.

Ammonium salts

Substance	Hazard	Comment
Ammonium chloride Solid and concentrated solution (*If 1.8 M or more*)	HARMFUL	Once called *sal ammoniac*. It decomposes on heating to form ammonia gas (see *Sheet 30*) and hydrogen chloride gas (see *Sheet 20*) but they recombine on cooling. Warming with alkali will generate ammonia gas.
Ammonium chloride Dilute solution (*If less than 1.8 M*)	LOW HAZARD	Warming with alkali will generate ammonia gas (see *Sheet 30).*
Ammonium sulfate(VI) Solid	LOW HAZARD	It decomposes on heating to form ammonia gas (see *Safety Sheet 30*) and sulfuric acid 'gas' (see *Sheet 22*) but they recombine on cooling. It is an approved food additive, E517. Warming with alkali will generate ammonia gas.
Ammonium carbonate Solid	HARMFUL	Also known as *sal volatile* or smelling salts. The solid decomposes, even at room temperature, to ammonia (see *Sheet 30*) and carbon dioxide (see *Sheet 58)*. It is an approved food additive, E503. Warming with alkali generates ammonia gas.
Ammonium carbonate Solution	LOW HAZARD	Warming with alkali generates ammonia gas (see *Sheet 30*).
Ammonium nitrate(V) Solid	OXIDISING	It may decompose explosively if heated; many industrial accidents have occurred in this way. Warming with alkali will generate ammonia gas (see *Sheet 30*).
Ammonium nitrate(V) Solution	LOW HAZARD	The solution does have oxidising properties. Warming with alkali will generate ammonia gas (see *Sheet 30*). Heating the solution to dryness produces fumes of nitrogen dioxide.
Ammonium dichromate(VI)		See *Student Safety Sheet 47.*

Typical control measures to reduce risk

- Wear eye protection when handling hazardous solids and solutions.
- Do **not** heat solid ammonium nitrate(V) and do **not** heat ammonium nitrate(V) solution to dryness.
- Avoid exposure to hazardous decomposition products if ammonium carbonate, chloride or sulfate(VI) are heated, eg, by using a fume cupboard.
- Avoid exposure to ammonia gas when reacting ammonium salts with alkalis, eg, by using a fume cupboard.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Specks of solid transferred into the eye, by rubbing with a contaminated finger.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should eye protection be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
• **Spilt on the floor, bench, etc**	Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.

Iron & its compounds

including **Iron(II) and iron(III) oxides, carbonates, sulfates(VI), chlorides, bromide**
Note: iron(II) compounds are often called **ferrous** and iron(III) compounds **ferric**

Substance	Hazard	Comment
Iron metal (filings, sheets or bars of metal)	LOW HAZARD	Iron filings or powder in the eye are very painful because the iron oxidises rapidly in the saline environment. Samples of iron are often not very pure and on reacting with dilute acids may produce toxic hydrogen sulfide gas (smelling of bad eggs). Iron is often coated with zinc (galvanised) to protect it from corrosion. For reaction with sulfur, see *Sheet 82.*
Iron metal (powder)	HIGHLY FLAMMABLE	
Iron oxides *or* **iron(II) carbonate**	LOW HAZARD	Applies to all iron oxides: iron(II) oxide, iron(III) oxide (haematite), iron(II) iron(III) oxide (magnetite). Iron(II) carbonate is usually sold mixed with a sugar (saccharated), to slow down oxidation.
Iron(II) sulfate(VI) *or* **ammonium iron(II) sulfate** Solid *or* concentrated solutions ***(If 1 M or more)***	HARMFUL	Harmful if swallowed. Usually solutions are made up in dilute sulfuric acid (which may itself be hazardous – see *Sheet 22*) to slow down oxidation. Ammonium iron(II) solutions are more stable but are still made up in acid to limit oxidation.
Iron(III) sulfate(VI) *or* **ammonium iron(III) sulfate** Solid *or* concentrated solutions ***(If 0.3 M or more)***	IRRITANT	Irritating to eyes and skin. . Usually solutions are made up in dilute sulfuric acid (which may itself be hazardous – see *Sheet 22*) to slow down formation of iron oxide. Ammonium iron(III) sulfate is sometimes known as ferric alum.
Iron(II) *or* **iron(III) sulfate(VI)** *or* **ammonium iron(II)** *or* **iron(III) sulfate** Dilute solutions *[If less than 1 M iron(II) or 0.3 M iron(III)]*	LOW HAZARD	Solutions which have been made up in sulfuric acid may be hazardous if the acid is more than 0.5 M (see *Sheet 22*).
Iron(II) *or* **iron(III) chloride** Hydrated or anhydrous solid *or* concentrated solutions ***(If 0.2 M or more).*** Includes etching solution (about 2 M).	HARMFUL / IRRITANT	Harmful if swallowed, irritating to skin, risk of serious damage to eyes. The solutions are classed as IRRITANT, the solids as HARMFUL. Some suppliers classify anhydrous solid iron(III) chloride as CORROSIVE. Usually solutions are made up in hydrochloric acid (see *Sheet 20*) to slow down oxidation.
Iron(II) *or* **iron(III) chloride** Dilute solutions ***(If less than 0.3 M)***	LOW HAZARD	-

Typical control measures to reduce risk

- Use the lowest possible quantities and concentrations.
- Take care not to rub the eye with fingers contaminated with iron filings or powder.
- Wear eye protection.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solutions spurting out of test tubes when heated or solutions heated to dryness and decomposing.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
Swallowed	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Dust breathed in	Remove the casualty to fresh air. See a doctor if breathing is difficult.
Spilt on the skin or clothing	Remove contaminated clothing and rinse it. Wash off the skin with plenty of water.
Spilt on the floor, bench, etc	Scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (eg, cat litter).

STUDENT SAFETY SHEETS 40

Copper & its compounds

including **Copper oxides, sulfate(VI), chloride, nitrate(V), carbonate**

Substance	Hazard	Comment
Copper (metal)	LOW HAZARD	-
Copper(I)/(II) oxides Cuprous or cupric oxide	☒ HARMFUL	They are harmful if swallowed; dust irritates the lungs and eyes.
Copper(II) sulfate(VI) or **nitrate(V)** Solid *or* concentrated solutions *(If 1 M or more)*	☒ HARMFUL	They are harmful if swallowed (especially saturated solutions for crystal-growing); the solid may irritate the eyes and skin. Water added to anhydrous solid sulfate(VI) produces heat.
Copper(II) sulfate(VI) or **nitrate(V)** Dilute solutions *(If less than 1 M)*	LOW HAZARD	Benedict's solution and Fehling's solution both contain dilute copper(II) sulfate(VI) but Fehling's solution has other hazards.
Copper(II) carbonate Solid *(Malachite)*	☒ HARMFUL	It is harmful if swallowed; dust irritates the lungs and eyes.
Copper(II) chloride Solid *or* concentrated solutions *(If 1.4 M or more)*	☒ HARMFUL	It is harmful if swallowed; solid may irritate the eyes and skin.
Copper(II) chloride Dilute solutions *(If less than 1.4 M)*	LOW HAZARD	-

Typical control measures to reduce risk

- Use the lowest possible quantities and concentrations.
- Avoid the use of copper(II) chloride if possible (except for electrolysis of the solution).
- Avoid raising dust (eg, by dampening powders).
- Take care if evaporating solutions to dryness.
- Wear eye protection.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solutions spurting out of test tubes when heated or solutions heated to dryness and decomposing.
- ***How serious would it be if something did go wrong?***
  Eg, Are there hazardous reaction products (such as chlorine from the electrolysis of copper chloride)?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

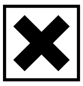
Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Dust breathed in**	Remove the casualty to fresh air. See a doctor if breathing is difficult.
• **Spilt on the skin or clothing**	Remove contaminated clothing and rinse it. Wash off the skin with plenty of water.
• **Spilt on the floor, bench, etc**	Scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (eg, cat litter).

STUDENT SAFETY SHEETS 41

Sodium chlorate(I)

also known as **Sodium hypochlorite**

Substance	Hazard	Comment
Concentrated sodium chlorate(I) Solution *(If more than 1.4 M* ***or*** *more than 10% (w/v) available chlorine)*	 CORROSIVE	It causes severe burns; it is especially dangerous to the eyes, similar to sodium hydroxide solution. **It produces a toxic gas (chlorine) with acids.** Pressure may build up in bottles during storage, due to slow decomposition. It removes the colour from many dyes.
Moderately-dilute sodium chlorate(I) Solution *(If between 1.4 M and 0.7 M* ***or*** *between 10% and 5% (w/v) available chlorine)*	 IRRITANT	This includes most domestic bleach. It is irritating to eyes and skin. **It produces a toxic gas (chlorine) with acids.** It removes the colour from many dyes.
Dilute sodium chlorate(I) Solution *(If less than 0.7 M* ***or*** *less than 5% (w/v) available chlorine)*	LOW HAZARD	It may still cause harm in eyes or in a cut. Microbiological spills can be dealt with using a 10% solution diluted 100 times (ie, 0.1%), but it is quickly made inactive by organic matter and so a 10 times dilution (ie, 1%) is often preferred.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest volume possible.
- Wear eye protection, including when making or disposing of solutions.
- Wear protective gloves if the concentrated solution is handled on anything larger than a test-tube scale.
- Never mix domestic bleach with other household cleaners, because these could be acidic.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Hazardous products of reaction (such as chlorine gas) are formed if sodium chlorate(I) is mixed with acid.
- ***How serious would it be if something did go wrong?***
  NB Alkali in the eye causes more damage than acid of equivalent concentration.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 20 minutes. See a doctor. If a visit to hospital is necessary, continue washing the eye during the journey in an ambulance.
• **Chlorine breathed in**	Remove the casualty to another room to rest. If more than a 'sniff' is inhaled, see a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Rinse contaminated clothing with water.
• **Spilt on the floor, bench, etc**	Wipe up small amounts with a damp cloth and rinse it well. For larger amounts, open the windows and, especially for quite-concentrated solutions, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Rinse with plenty of water.

STUDENT SAFETY SHEETS 42

Barium compounds

Substance	Hazard	Comment
Barium chloride Solid	☠ TOXIC	Until recently, it was classed as HARMFUL if swallowed or if dust is breathed in. It is irritating to the eyes, skin, lungs etc.
Barium chloride Solution *(If 1 M or more)*	☠ TOXIC	Until recently, it was classed as HARMFUL if swallowed. It is irritating to the eyes, skin, lungs etc.
Barium chloride Solution *(If 0.1 M or more but less than 1 M)*	✖ HARMFUL	It is harmful if swallowed and irritating to the eyes, skin, lungs etc.
Barium chloride Solution *(If less than 0.1 M)*	LOW HAZARD	-
Barium nitrate(V) Solid	🔥 ✖ OXIDISING / HARMFUL	It is harmful if swallowed and inhaled.
Barium nitrate(V) Solution	LOW HAZARD	-
Barium sulfate(VI) Solid	LOW HAZARD	Unlike most barium compounds, barium sulfate(VI) is LOW HAZARD because it does not dissolve in water or acids. Hence it is safe to eat a 'barium (sulfate) meal', before being X-rayed.

Typical control measures to reduce risk

- Use the lowest concentration possible.
- Use the smallest quantity possible.
- Wear eye protection.
- Wash hands after handling barium compounds.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Somebody drinking a toxic solution by mistake.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
Swallowed	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Spilt on the skin or clothing	Brush off any solid. Remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. Rinse contaminated clothing with water.
Spilt on the floor, bench, etc	Scoop up any solid. Rinse the area with water, diluting greatly. Solutions should be treated with mineral absorbent (eg, cat litter).

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STUDENT SAFETY SHEETS 43

Lead & its compounds

including **Lead oxides, bromide, nitrate(V), ethanoate (acetate) etc**

Substance	Hazard	Comment
Lead (metal)	LOW HAZARD	Wash hands after handling lead metal.
Lead compounds Solids	☠ TOXIC	These are harmful if swallowed or dust is breathed in. They may accumulate over time. They may harm unborn children (ie, act as teratogens). Lead ethanoate (acetate) may reduce fertility & may cause cancer. Lead chromate(VI) (used in the yellow lines on roads) may cause cancer. Young children may be at risk if they chew old objects painted with a lead-based paint. When burnt in cars, leaded petrol produces particles of lead compounds. (They are also DANGEROUS FOR THE ENVIRONMENT because they are very toxic to aquatic organisms.)
Lead compounds Solutions of lead salts in water (*If 0.01 M or more*)	☠ TOXIC	They are harmful; there is a danger of serious damage to health by prolonged exposure if swallowed. They may accumulate over time. They may harm unborn children (teratogens). Lead ethanoate (acetate) may reduce fertility & may cause cancer.
Lead compounds Extremely-dilute solutions of lead salts in water (*If less than 0.01 M*)	LOW HAZARD	They may accumulate over time. In soft-water areas, lead pipes may very slowly dissolve.

Typical control measures to reduce risk

- Wear eye protection; use the lowest possible amounts and concentrations.
- Preferably, heat lead compounds in a fume cupboard; avoid raising dust (eg, by dampening powders).
- Less-volatile compounds (eg, oxides) may be heated in small amounts in a well-ventilated room (but not if those who are, or who might be, pregnant are present).
- Use lead nitrate rather than lead ethanoate (acetate) when a soluble lead salt is needed.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solution spurts out of a test tube when heated or dust is breathed in.
- ***How serious would it be if something did go wrong?***
  Eg, Could anybody be exposed to dangerous lead levels for long periods of time?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush off as much solid as possible. Remove contaminated clothing. Wash the skin and clothes with large quantities of water.
• **Spilt on the floor, bench, etc**	Scoop up solid. Rinse the area with water, diluting very greatly. Solutions should be treated with mineral absorbent (eg, cat litter).

Mercury & its compounds

including Mercury(I/II) oxides, chlorides, nitrates(V), etc

Substance	Hazard	Comment
Mercury Liquid metal	☠ TOXIC	Its vapour is toxic if breathed in over long periods of time. Spills should be cleared up promptly, but there is no reason to panic. One thermometer contains little mercury and dangerous levels rarely arise in schools. Wear gloves when handling mercury. It forms alloys with gold, silver, etc (eg, jewellery) - remove rings. (It is also DANGEROUS FOR THE ENVIRONMENT because it is very toxic to aquatic organisms.)
Mercury compounds Solid	☠ VERY TOXIC	These are very toxic if dust is breathed in, in contact with the skin or if swallowed. They may irritate the eyes and skin. Vomiting and 'feeling sick' are early signs of poisoning. Mercury ('button') batteries contain mercury oxide and should be recycled. (They are also DANGEROUS FOR THE ENVIRONMENT because they are very toxic to aquatic organisms.)
Mercury compounds Solutions in water (*If 0.04 M or more*)	☠ TOXIC	They are toxic if in contact with the skin or if swallowed. They may irritate the eyes and skin. Vomiting and 'feeling sick' are early signs of poisoning. Mercury compounds used in making Victorian hats caused disease, as in the 'Mad hatter' of *Alice in Wonderland*.
Mercury compounds Solutions in water (*If less than 0.04 M but 0.004 M or more*)	✖ HARMFUL	They are harmful in contact with the skin or if swallowed. They may irritate the eyes and skin. Pollution by mercury compounds in a Japanese river in the 1950s caused serious poisoning of humans who ate fish from the river (Minimata disease).
Mercury compounds (*If less than 0.004 M*)	LOW HAZARD	This only applies to extremely-dilute solutions in water.

Typical control measures to reduce risk

- Wear eye protection and suitable gloves; use the lowest possible concentration.
- Avoid the use of mercury compounds where possible (eg, avoid Millon's reagent).
- Handle liquid mercury over a tray to contain spills; do not leave mercury surfaces exposed to the air.
- Avoid raising dust (eg, by dampening powder); work in a fume cupboard.
- Clear up spills promptly and with care.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solution spurts out of a test tube when heated, mercury metal spills on the floor or a thermometer is broken.
- ***How serious would it be if something did go wrong?***
  Eg, Could anybody be exposed to dangerous mercury levels for long periods of time?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
Swallowed	There is little problem with mercury metal (but see a doctor). For compounds, do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Vapour breathed in	Dangerous only if large amounts of vapour are breathed in over a short period of time (eg, when heating metal) or from long-term exposure. See a doctor.
Spilt on the skin or clothing	For mercury metal, remove contaminated clothing and wash off the skin. Check jewellery for damage. For mercury compounds, flood the area with large amounts of water. Remove and repeatedly rinse clothing. See a doctor for large areas affected or if blistering occurs.
Spilt on the floor, bench, etc	For mercury metal, remove jewellery, collect up mechanically (eg, with asyringe). Mop up the remainder with a hot paste of 1:1 calcium oxide/sulfur mixture in water. Spread the same (dry) mixture over cracks and other inaccessible areas. For compounds, scoop up the solid. Rinse the area with water, diluting very greatly. For solutions, use mineral absorbent (eg, cat litter).

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STUDENT SAFETY SHEETS 45

Aluminium & its compounds

including **Aluminium oxide, hydroxide, sulfate(VI) and chloride;** *also* **Potash alum**

Substance	Hazard	Comment
Aluminium (metal) Solid (large pieces, sheets, etc)	LOW HAZARD	It is used in cooking utensils and is generally considered safe. There were suggestions at one time that aluminium might cause Alzheimer's disease but these are now considered unlikely.
Aluminium (metal) Fine powder	HIGHLY FLAMMABLE	Eg, it is used as a food additive E173. Under suitable conditions, it may react with water to produce hydrogen, an extremely flammable gas (see *Sheet 50*). A dust explosion is possible if it is exposed to flame. Although difficult to ignite, it is difficult to extinguish.
Aluminium oxide (alumina), or **aluminium hydroxide**	LOW HAZARD	It is used in indigestion tablets.
Aluminium sulfate(VI) or **aluminium potassium sulfate(VI) (potash alum)** Solid or solution	LOW HAZARD	Solutions are acidic. They are added in small amounts to cloudy water in reservoirs to coagulate clay particles. When large amounts were accidentally added to a reservoir at Camelford in Cornwall, some ill effects were reported. It is used as a mordant in dyeing.
Aluminium chloride Anhydrous solid	CORROSIVE	It causes burns. It reacts violently and exothermically with water to produce fumes of hydrogen chloride (see *Sheet 20*). Pressure may build up in a closed container due to absorbed moisture.
Aluminium chloride Hydrated solid or moderately-concentrated solution *(If 0.8 M or more)*	IRRITANT	The solution is acidic. It is irritating to the eyes and skin.
Aluminium chloride Dilute solution *(If less than 0.8 M)*	LOW HAZARD	In antiperspirants and deodorants, it is mixed with other substances and is not classed as hazardous. However, it may be an IRRITANT to people with sensitive skin.

Typical control measures to reduce risk

- Use the lowest possible concentration; wear eye protection.
- Avoid the use of aluminium powder or anhydrous aluminium chloride if possible.
- Avoid raising dust and keep aluminium powder away from naked flames.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solution spurts out of a test tube when heated or a solution decomposes when heated to dryness.
- ***How serious would it be if something did go wrong?***
  Eg, Are there hazardous reaction products, eg, hydrogen chloride gas from the action of water on anhydrous aluminium chloride?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Dust breathed in**	Remove the casualty to fresh air. See a doctor if breathing is difficult.
• **Spilt on the skin or clothing**	Remove and rinse contaminated clothing. Wash off the skin with plenty of water.
• **Spilt on the floor, bench, etc**	Scoop up the solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with a cloth.
• **Fire**	Powdered aluminium fires should be extinguished by smothering with clean, dry sand.

Silver & its compounds

including **Silver bromide, chloride, iodide, nitrate(V) and oxide**

Substance	Hazard	Comment
Silver (metal) Solid	LOW HAZARD	It is used in jewellery. It is an approved food additive, E174.
Silver halides, ie, **silver bromide, silver chloride** and **silver iodide** Solids	LOW HAZARD	They are widely used in photographic emulsions. They are decomposed by light to give silver metal and the halogen.
Silver nitrate(V) Solid and fairly-concentrated solutions *(If 0.5 M or more)*	CORROSIVE	It causes burns and is dangerous to the eyes. If swallowed, it causes internal damage due to absorption into the blood, followed by deposition of silver in various tissues. It produces black stains on the skin, which, however, wear off in a few days. The solid explodes dangerously with magnesium powder and a drop of water. (It is also DANGEROUS FOR THE ENVIRONMENT because it is very toxic to aquatic organisms.)
Silver nitrate(V) Fairly-dilute solutions *(If less than 0.5 M but 0.2 M or more)*	IRRITANT	It may produce black stains on the skin, which, however, wear off in a few days.
Silver nitrate(V) Dilute solutions *(If less than 0.2 M)*	LOW HAZARD	Very dilute solutions are adequate for most school work when testing for halides in solution.
Silver nitrate(V) Ammoniacal solution (Tollen's Reagent)	IRRITANT / EXPLOSIVE	It is used for aldehyde tests and should be prepared **only on a test-tube scale**, when needed, and discarded into plenty of water within ½ hour, otherwise explosives may form.
Silver oxide Solid	LOW HAZARD	It is used in some batteries, eg, button cells for watches and calculators.

Typical control measures to reduce risk

- Use the lowest possible concentration; wear eye protection.
- Avoid keeping solutions of silver compounds and ammonia for more than a few minutes.
- Avoid handling solid silver nitrate.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Silver nitrate accidentally coming into contact with the skin.
- ***How serious would it be if something did go wrong?***
  Eg, Are there hazardous reaction products, eg, from solutions of silver compounds with ammonia?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn? Are gloves needed?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing and rinse it. Wash off the skin with plenty of water. If the silver nitrate produces more than small burns, see a doctor.
• **Spilt on the floor, bench, etc**	Wear eye protection and gloves. Scoop up the solid. Rinse the area with water and wipe up, rinsing repeatedly. Rinse the mop or cloth thoroughly.

Chromium & its compounds

including **Chromium(III) salts, chrome alum, chromates and dichromates**

Substance	Hazard	Comment
Chromium (metal) Solid	LOW HAZARD	It is used (as chromium plate) to give a shiny, protective surface on steel, eg, on cars and bicycles.
Chromium(III) oxide Solid	LOW HAZARD	It is used as a green pigment, eg, in pottery.
Chromium(III) salts Solid and most solutions *(If 0.5 M or more)*	☒ HARMFUL	These include chromium potassium sulfate(VI) (chrome alum). They are harmful if swallowed and irritating to the eyes and skin.
Chromium(III) salts Dilute solutions *(If less than 0.5 M)*	LOW HAZARD	These include chromium potassium sulfate(VI) (chrome alum).
Potassium/sodium chromate(VI)/dichromate(VI) Solid and most solutions (*If 0.2 M or more*)	☠ 🔥 VERY TOXIC / OXIDISING	These are very toxic by inhalation or if swallowed. They may cause sensitisation and/or ulcers in contact with the skin. They may cause cancer by inhalation but inhalation is unlikely in most school uses. Oxidation, eg, of alcohols, may be quite violent. (They are also DANGEROUS FOR THE ENVIRONMENT because they are very toxic to aquatic organisms.)
All chromates(VI)/ dichromates(VI) *Solutions less than 0.2 M but 0.003 M or more.*	☠ 🔥 TOXIC / OXIDISING	They are toxic by inhalation or if swallowed. They may cause sensitisation and/or ulcers in contact with the skin. They may cause cancer by inhalation but inhalation is not at all likely in most school uses.
All chromates(VI)/ dichromates(VI)	LOW HAZARD	This only applies to any solutions less than 0.003 M.
Ammonium dichromate(VI) Solid	☠ 💥 VERY TOXIC / EXPLOSIVE	In addition to the hazards of potassium/sodium salts, this decomposes if heated and will explode in confined spaces. It is used in indoor fireworks.
Lead chromate(VI) Solid	☠ TOXIC	It is used as the pigment for yellow lines on roads. There is limited evidence of carcinogenic effects. It may cause harm to the unborn child. See *Sheet 43*.

Typical control measures to reduce risk

- Use the lowest possible concentration; wear eye protection; consider the use of gloves for chromates/dichromates.
- For the volcano experiment, prevent exposure to dust by the use of a fume cupboard or mineral-wool plug in the vessel.
- Avoid inhaling chromate/dichromate dust or spray (eg, during electrolysis).

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Chromate or dichromate dust or solution are accidentally inhaled.
- ***How serious would it be if something did go wrong?***
  Eg, Are there hazardous reactions, eg, violent oxidations or decompositions?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn? Are gloves needed?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing and rinse it until no colour remains. Wash off the skin with plenty of water. If skin contamination is more than small, see a doctor.
• **Spilt on the floor, bench, etc**	Wear eye protection and gloves. Scoop up the solid. Rinse the area with water and wipe up, rinsing repeatedly until no colour remains. Rinse the mop or cloth thoroughly.

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STUDENT SAFETY SHEETS 48

Manganese & its compounds

including **Manganese(IV) oxide (dioxide)** *&* **Potassium manganate(VII) (permanganate)**

Substance	Hazard	Comment
Manganese (metal) Solid	HARMFUL	It is harmful by inhalation, hence exposure to dust or fume would present a risk but not bulk metal.
Manganese(II) salts Solid and concentrated solutions *(If about 1 M or more)*	HARMFUL	These include manganese(II) chloride and sulfate(VI). Manganese(II) carbonate is considered LOW HAZARD.
Manganese(II) salts Dilute solutions *(If less than about 1 M)*	LOW HAZARD	These include manganese(II) chloride and sulfate(VI).
Manganese(IV) oxide (Manganese dioxide) Solid	HARMFUL	It is harmful by inhalation or if swallowed. It is often used as a fine powder. Many hazardous reactions occur with reducing agents or concentrated acids. It is used in dry cells (batteries).
Potassium manganate(VII) (permanganate) Solid	HARMFUL / OXIDISING	It is harmful if swallowed and stains the hands and clothing. Many hazardous reactions occur with reducing agents or concentrated acids. On heating, it liberates oxygen gas and releases a fine dust of potassium manganate(VI).
All manganates(VII) (permanganates) Solutions	LOW HAZARD	They stain hands and clothing.

Typical control measures to reduce risk

- Wear eye protection.
- Avoid inhaling dusts.
- Avoid skin contact, especially with manganates(VII).
- Avoid contact between manganates(VII) or manganese(IV) oxide and concentrated acids or reducing agents.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Dust is accidentally inhaled.
- ***How serious would it be if something did go wrong?***
  Eg, Are there hazardous reactions, eg, violent oxidations or decompositions?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn? Are gloves needed?

Emergency action

In the eye	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
Swallowed	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Spilt on the skin or clothing	Remove contaminated clothing and rinse it. Wash off the skin with plenty of water. [Manganate(VII) will give permanent stains to clothing and the skin.] If skin contamination is more than small, see a doctor.
Spilt on the floor, bench, etc	Wear eye protection and gloves. Scoop up the solid. Rinse the area with water and wipe up, rinsing repeatedly. [Manganate(VII) will give permanent stains.] Rinse the mop or cloth thoroughly.

Zinc & its compounds

including **Zinc oxide, carbonate, sulfate(VI), chloride, bromide**

Substance	Hazard	Comment
Zinc metal (granulated or sheets of metal)	LOW HAZARD	Pure zinc does not react readily with dilute acids, without a catalyst [usually copper(II) sulfate]. Iron or steel is often coated with zinc (galvanised) to protect it from rusting.
Zinc metal (powder or dust)	HIGHLY FLAMMABLE	Under suitable conditions may react with water to produce extremely flammable gas (see *Sheet 50*). Can ignite spontaneously in air or react violently with iodine, sulfur and copper(II) oxide. Most school samples have a surface coating of zinc oxide, making reactions unpredictable.
Zinc oxide *or* **carbonate**	LOW HAZARD	The zinc oxide fumes ('philosopher's wool') formed when zinc dust burns in air are regarded as hazardous dust.
Zinc sulfate(VI) Solid *or* concentrated solutions *(If 0.4 M or more)*	HARMFUL / IRRITANT	Harmful if swallowed (especially saturated solutions for crystal-growing). There is a risk of serious damage to the eyes. When preparing zinc sulfate by reacting zinc and sulfuric acid, the reaction can be slow and is often incomplete.
Zinc sulfate(VI) Dilute solutions *(If less than 0.4 M)*	LOW HAZARD	
Zinc chloride *or* **bromide** Solid *or* concentrated solutions *(If 0.7 M or more)*	CORROSIVE	These cause burns and are harmful if swallowed. The anhydrous solids are especially dangerous. The solids absorb water from the atmosphere. Electrolysis of molten zinc chloride/bromide or solutions produce chlorine or bromine.
Zinc chloride *or* **bromide** Fairly dilute solutions *(If less than 0.7 M but more than 0.3 M)*	IRRITANT	-
Zinc chloride *or* **bromide** Dilute solutions *(If less than 0.3 M)*	LOW HAZARD	-

Typical control measures to reduce risk

- Use the lowest possible quantities and concentrations.
- Only electrolyse zinc chloride/bromide solutions briefly, unless in a fume cupboard (essential for the molten compounds).
- Assume zinc powder/dust is fresh and not partially oxidised on the surface.
- When reacting zinc and acid, check no acid remains before evaporating solutions (pH should be 4 or higher).
- Wear eye protection.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Solutions spurting out of test tubes when heated or solutions heated to dryness and decomposing.
- ***How serious would it be if something did go wrong?***
  Eg, Are there hazardous reaction products (such as chlorine from the electrolysis of zinc chloride)?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Dust breathed in**	Remove the casualty to fresh air. See a doctor if breathing is difficult.
• **Spilt on the skin or clothing**	Remove contaminated clothing and rinse it. Wash off the skin with plenty of water.
• **Spilt on the floor, bench, etc**	Scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (eg, cat litter).

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STUDENT SAFETY SHEETS

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Hydrogen

Substance	Hazard	Comment
Hydrogen Gas	EXTREMELY FLAMMABLE	It forms explosive mixtures with air and oxygen. Mixtures with air between 4% and 74% hydrogen by volume are explosive. Explosive mixtures will ignite below 500 °C and well below this temperature in the presence of catalysts such as transition metals and their oxides. The explosion with oxygen produces a **very** loud noise which can damage hearing. Mixtures of hydrogen and oxygen can arise when recharging a car battery (or model cells in schools); ensure good ventilation, avoid sparks and naked flames.

Typical control measures to reduce risk

- If preparing the gas in test- tube reactions, use the smallest possible amounts.
- Wear eye protection and stand well back.
- Use safety screens for all but test-tube amounts of the gas; ensure good laboratory ventilation.
- If preparing the gas on anything larger than a test-tube scale, make sure the apparatus has the smallest possible volume, so that only a little air has to be flushed out. If lighting the gas at a jet, test a sample to make sure that all the air has been flushed out and light from a distance.
- If possible, use a gas cylinder rather than generate your own hydrogen, because the cylinder produces a more-rapid flow which flushes air more quickly from the apparatus.
- When reducing, eg, metal oxides, consider alternative reducing agents such as methane or ammona gas.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could the hydrogen be ignited accidentally? How easy is it to make sure that all the air has been flushed out?
- ***How serious would it be if something did go wrong?***
- *NB There are occasional reports of pupils being taken to hospital (for treatment to cuts or for splashes of chemicals) as a result of damage to apparatus in hydrogen explosions.*
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **Gas escape**	Open all the windows. Make sure there are no naked flames.
• **Explosion**	If there are cuts from flying glass, apply pressure using a clean pad of cloth. Do **not** attempt to remove large pieces of embedded glass, etc. If there is arterial bleeding, the casualty should be laid down and the injured limb raised up. Send for a doctor.

STUDENT SAFETY SHEETS 51

Oxygen & Ozone

Substance	Hazard	Comment
Oxygen Gas	OXIDISING	Air contains about 21% oxygen. Contact between oxygen and combustible material may cause fire. Combustible substances burn much more fiercely in air which has been only slightly enriched with oxygen (eg, 25%). Products of combustion are often strongly acidic or basic (alkaline) oxides. If the amount of oxygen in the air becomes too low, headaches, unconsciousness and death may result. First effects may be noticed when the percentage drops to 18%. Similar effects may be observed on high mountains due to lower pressure.
Ozone Gas	OXIDISING TOXIC IRRITANT	It is toxic if breathed in. It irritates the eyes and respiratory system. For a 15-minute exposure, the concentration in the atmosphere should not exceed 0.4 mg m^{-3}. It is not normally made or used in school science. In the presence of sunlight, traces of hydrocarbons in the air react with nitrogen oxides (see *Sheet 53*), eg, from car exhausts, to form ozone. This causes photochemical smog in certain hot weather conditions. Small amounts of ozone are also formed in some photocopiers but this is only likely to be a problem in a small room with poor ventilation. Although dangerous if breathed in, ozone in the upper atmosphere performs a very important safety role, where it absorbs much of the ultraviolet radiation reaching the earth, thus preventing dangerous exposures (see *Sheet 12*). There is considerable concern that pollution by certain chlorinated hydrocarbons (see *Sheet 62*) is destroying the ozone layer.

Typical control measures to reduce risk

- Wear eye protection when preparing oxygen or burning substances in oxygen.
- Avoid looking directly at the very bright light from magnesium burning in oxygen.
- Avoid inhaling products when non-metals are burning in oxygen.
- Use safety screens when burning substances in oxygen on anything larger than a test-tube scale.
- If using cylinders of oxygen, do **not** lubricate controls with oil or grease as this might catch fire.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could substances burn much more fiercely than expected?
- ***How serious would it be if something did go wrong?***
  Eg, Would there be widespread health effects if the ozone layer is damaged by pollution?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **Gas escape**	If a large quantity is released, open all windows. Extinguish all naked flames.
• **Clothing catches fire**	Smother flames on clothing or the skin with a fire blanket or other material. Cool any burnt skin with gently-running tap water for 10 minutes. See a doctor if the area of burn is larger than a small coin.
• **Other fires**	Allow fires in sinks etc to burn out. Fires at the top of test tubes, beakers, etc should be smothered with a damp cloth or heat-proof mat.

Sulfur dioxide

Substance	Hazard	Comment
Sulfur dioxide Gas	☠ TOXIC	It is toxic if breathed in. It may cause burns and it irritates the eyes and respiratory system. It is a choking gas and may trigger an asthma attack (even some hours after exposure). For a 15-minute exposure, the concentration of the gas in the atmosphere should not exceed 2.7 mg m^{-3}. It is produced naturally in large amounts by volcanoes. Most fossil fuels contain traces of sulfur compounds. When burnt, these result in sulfur dioxide released into the atmosphere, causing acid rain. It may be produced in the laboratory by the action of heat or dilute acid on sulfites or thiosulfates. It is used in small amounts as a preservative in some foodstuffs and wines.
Sulfur dioxide Dilute solution in water	LOW HAZARD (BUT BEWARE OF TOXIC GAS GIVEN OFF)	The gas is very soluble in water and may cause suck back. Alternatively, a sulfur dioxide solution can be prepared using sodium metabisulfite and adding sulfuric acid. The gas escapes easily from solution, especially if this is warmed, and should not be inhaled.

Typical control measures to reduce risk

- If preparing the gas in test-tube reactions, use the smallest amounts possible.
- Wear eye protection.
- Take steps to prevent suck back of water, eg, by the use of Bunsen valves.
- Use a fume cupboard for anything larger than test-tube amounts of gas; ensure good laboratory ventilation and quickly dispose of solutions containing sulfur dioxide.
- If testing for the gas by its smell, follow the safe technique for sniffing gases: use your hand to waft the gas towards your nose.
- Do **not** expose asthmatics to the gas.
- Use fuels which are naturally low in sulfur, remove sulfur compounds before use or use scrubbers to absorb sulfur dioxide from the exhaust gases of coal- or oil-burning power stations.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, A leak of gas into the laboratory from apparatus or a warmed solution, or suck back.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
Vapour breathed in	Remove the casualty to fresh air. Call a doctor if breathing is difficult.
Gas escape in a laboratory	Open all windows. If over 1 litre of gas is released, evacuate the laboratory.

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STUDENT SAFETY SHEETS 53

Nitrogen oxides

includes **Nitrogen monoxide, Nitrogen dioxide, Dinitrogen tetroxide** *&* **Dinitrogen oxide**

Substance	Hazard	Comment
Nitrogen monoxide (Nitric oxide; NO) Gas	☠ VERY TOXIC	It is very toxic if breathed in and irritates the eyes and respiratory system. For a 15-minute exposure, the concentration in the atmosphere should not exceed 1.4 mg m^{-3}. It reacts with oxygen in the atmosphere to form nitrogen dioxide (see below). It may be formed by the reaction between oxygen and nitrogen in the air, especially in car engines. This is a major contributor to acid rain and photochemical smog. The mixture of NO and NO_2 formed in this way is often referred to as NO_X.
Nitrogen dioxide (NO_2) **Dinitrogen tetroxide (N_2O_4)** Gases	☠ VERY TOXIC CORROSIVE	These are very toxic if breathed in. They may cause dizziness, headaches and coldness. They also irritate the eyes and respiratory system. Serious effects may be delayed until after apparent recovery. They may trigger an asthma attack. For a 15-minute exposure, the concentration in the atmosphere should not exceed 1.9 mg m^{-3}. They are formed as air pollutants from nitrogen monoxide (see above). They are formed in the laboratory by the action of heat on many nitrates and by the reaction of nitric acid on some metals. They are very soluble in water; there is a risk of suck back.
Dinitrogen oxide (N_2O) 'Laughing gas'	OXIDISING	This is an anaesthetic in large amounts. It has been used as a general anaesthetic, eg, by dentists.

Typical control measures to reduce risk

- If preparing gases in test-tube reactions, use the smallest possible amounts and take steps to avoid suck back.
- Wear eye protection.
- Use a fume cupboard for anything larger than test-tube amounts of gas; ensure good laboratory ventilation.
- If testing for the gases by their smell, follow the safe technique for sniffing gases: use your hand to waft the gas towards your nose.
- Prevent exposure to the gases by asthmatics.
- Use catalytic converters in car exhausts to reduce the amount of nitrogen oxides released into the air.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Leak of a gas from apparatus into the laboratory atmosphere.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if breathing is difficult.
• **Gas escape in a laboratory**	Open all windows. If over 1 litre of gas is released, evacuate the laboratory.

Chlorine

includes Chlorine water

Substance	Hazard	Comment
Chlorine Gas	 TOXIC  DANGEROUS FOR THE ENVIRONMENT	This is toxic if breathed in, causing severe lung damage. It irritates the eyes, skin and respiratory system. It may trigger an asthma attack and the effects of exposure may be delayed for some hours. For a 15-minute exposure, the concentration of the gas in the atmosphere should not exceed 1.5 mg m^{-3}. It is very toxic to the aquatic environment and is used to kill microbes in public water supplies, at a concentration between about 0.1 and 1.0 mg per litre. It is also used to treat swimming pool water at a concentration between about 1.4 and 4.0 mg per litre. It may be formed in the laboratory by electrolysis and the oxidation of some chlorides. It may be formed in the laboratory, in the home or at work by the action of acid on bleaches; see *Sheet 41*.
Chlorine water Solution in water	LOW HAZARD (BUT BEWARE OF TOXIC GAS GIVEN OFF)	It can be made in a fume cupboard by diluting a saturated solution with a little more than its own volume of water. Chlorine gas escapes easily from the solution, especially if it is warmed.

Typical control measures to reduce risk

- If preparing the gas in test-tube reactions, use the smallest possible amounts; where possible, absorb excess gas with a soda lime tube.
- Wear eye protection.
- Use a fume cupboard for anything larger than test-tube amounts; ensure good laboratory ventilation.
- If testing for the gas by its smell, follow the safe technique for sniffing gases: use your hand to waft the gas towards your nose.
- Prevent exposure to the gas by asthmatics. Even with chlorine water, take care not to breathe in chlorine.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
- ***How serious would it be if something did go wrong?***
  NB There are occasional reports of pupils being taken to hospital as a result of breathing in chlorine.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if breathing is even slightly affected.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	For chlorine water, remove contaminated clothing and rinse it. Then drench the skin with plenty of water.
• **Spilt on the floor, bench, etc**	Open all windows. For a release of more than 1 litre of chlorine gas, evacuate the laboratory. Mop up chlorine water and rinse with plenty of water.

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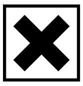
Bromine

includes **Bromine water**

Substance	Hazard	Comment
Bromine Liquid	 VERY TOXIC / CORROSIVE	It produces a vapour which is very toxic if breathed in. The liquid causes severe burns to the eyes and skin. For a 15-minute exposure, the concentration of the vapour in the atmosphere should not exceed 1.3 mg m^{-3}.
Concentrated bromine solution, in organic solvents *(If 0.3 M or more)*	 VERY TOXIC / CORROSIVE	It produces a vapour which is very toxic if breathed in. The solution causes severe burns to the eyes and skin. There may also be hazards associated with the organic solvent; see relevant *Student Safety Sheets.*
Moderately-concentrated bromine solution, in water or organic solvents *(If 0.06 M or more but less than 0.3 M)*	 TOXIC / IRRITANT	It produces a vapour which is very toxic if breathed in. The solution causes severe burns to the eyes and skin. A saturated solution in water is about 0.25 M. There may also be hazards associated with the organic solvent; see relevant *Student Safety Sheets.*
Moderately-dilute bromine solution, in water or organic solvents *(If 0.006 M or more but less than 0.06 M)*	 HARMFUL	There may be hazards associated with the organic solvent; see relevant *Student Safety Sheets.*
Very dilute bromine solution, in water or organic solvents *(If less than 0.006 M)*	LOW HAZARD	There may be hazards associated with the organic solvent; see relevant *Student Safety Sheets.* This concentration is suitable for testing alkenes for unsaturation.

Typical control measures to reduce risk

- Use the lowest concentration and smallest volume possible.
- Wear eye protection and protective nitrile gloves for all but the most-dilute solutions.
- **Avoid breathing the fumes from concentrated solutions, eg, by the use of a fume cupboard.**
- When bromine liquid is in use, have plenty of sodium thiosulfate solution available to deal with spills.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if breathing is even slightly affected.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	For liquid bromine or the moderately-concentrated solution, immerse in sodium thiosulfate solution (20%, 1 M). Remove contaminated clothing, soak it and drench the skin with plenty of water. See a doctor.
• **Spilt on the floor, bench, etc**	**For spills of all but a few drops of liquid bromine, open windows and evacuate the laboratory.** For small bromine spills, add sodium thiosulfate solution (20%. 1 M) and leave for 1 hour. Mop up and rinse with plenty of water.

Iodine

includes Iodine solutions

Substance	Hazard	Comment
Iodine Solid	☒ HARMFUL	It is harmful if breathed in or by contact with the skin. It causes burns to the skin if left for some time. It is easily vapourised if heated - the violet vapour is dangerous to the eyes. For a 15-minute exposure, the concentration in the atmosphere should not exceed 1.1 mg m^{-3}. (It is also DANGEROUS FOR THE ENVIRONMENT because it is very toxic to aquatic organisms.)
Iodine solution, in potassium iodide / water or in organic solvent *(If 1 M or more)*	☒ HARMFUL	There may be hazards associated with the organic solvent; see relevant *Student Safety Sheets.* Ethanol is often used; it is HIGHLY FLAMMABLE.
Dilute iodine solution, in potassium iodide / water or in organic solvent *(If less than 1 M)*	LOW HAZARD	There may be hazards associated with the organic solvent; see relevant *Student Safety Sheets.* Ethanol is often used; it is HIGHLY FLAMMABLE. 'Tincture of iodine', used as a mild antiseptic, is a dilute solution in ethanol (about 0.1 M).

Typical control measures to reduce risk

- Use the lowest concentration and smallest amount possible.
- Wear eye protection for all but the most-dilute solutions.
- Handle iodine solid using forceps or, better, wear protective gloves as well.
- **Avoid breathing iodine vapour, eg, by the use of a fume cupboard.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
- ***How serious would it be if something did go wrong?***
  NB Iodine vapour can crystallise painfully on the eye.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if breathing is even slightly affected.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush off solid iodine and immerse in sodium thiosulfate solution (20%, 1 M). Remove contaminated clothing, soak it and drench the skin with plenty of water. See a doctor if a large area is affected or blistering occurs.
• **Spilt on the floor, bench, etc**	Scoop up any solid iodine, add sodium thiosulfate solution (20%, 1 M) to the remaining spill and leave for 1 hour. Mop up and rinse with plenty of water.

Hydrogen peroxide

Substance	Hazard	Comment
Concentrated hydrogen peroxide solution *[If less than 13.6 M, ie, '170 volume strength' (50%) but 2.3 M or more, ie, over '28 volume strength' (8%)]*	☒ HARMFUL	It is harmful if swallowed. There is a risk of serious damage to the eyes. The most-concentrated solution found in schools is normally in this category. It decomposes slowly to produce oxygen gas (see *Sheet 51*); pressure may build up and care needs to be taken when opening a bottle. It should be stored in the dark. Decomposition is speeded up by catalysts such as some metal oxides and some enzymes. The oxygen formed will assist fires.
Dilute hydrogen peroxide solution *[If less than 2.3 M but 1.5 M or more, ie, less than '28 volume strength' (8%) but '18 volume strength' (5%) or more]*	☒ IRRITANT	It irritates the eyes and skin. The typical concentration used in school science practical work. It decomposes slowly to produce oxygen gas (see *Sheet 51*); pressure may build up and care needs to be taken when opening a bottle. It should be stored in the dark. Decomposition is speeded up by catalysts such as some metal oxides and some enzymes.
Very dilute hydrogen peroxide solution *[If less than 1.5 M, ie, less than '18 volume strength' (5%)]*	LOW HAZARD	It is used for bleaching hair. It decomposes slowly to produce oxygen gas (see *Sheet 51*); pressure may build up and care needs to be taken when opening a bottle. It should be stored in the dark. Decomposition is speeded up by catalysts such as some metal oxides and some enzymes. Old stock may have insufficient peroxide molecules for the intended activity.

Typical control measures to reduce risk

- Use the lowest concentration and smallest volume possible.
- Wear eye protection for all but the most-dilute solutions.
- Store concentrated solutions away from heat and light, in bottles with special vented caps. Beware of a rapid release of pressure when opening a bottle.
- Avoid accidental contamination of solutions which may speed up the formation of oxygen and pressure build-up.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could an impurity / catalyst cause rapid decomposition and frothing?
- ***How serious would it be if something did go wrong?***
  Eg, If the solution splashes onto the skin, is it sufficiently concentrated to cause burns?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Flood the area with plenty of water. Remove contaminated clothing and soak it. If a large area is affected or blistering occurs, see a doctor.
• **Spilt on the floor, bench, etc**	For large spills, and especially for (moderately) concentrated solutions, cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Dilute with at least ten times its own volume of water. Rinse the floor etc with plenty of water. Wipe up small amounts with a damp cloth and rinse it well.

Carbon & its oxides

including **carbon dioxide, carbon monoxide**

Substance	Hazard	Comment
Carbon dioxide Gas	DANGER	It can cause asphyxiation if the proportion of carbon dioxide in the air becomes too high, eg, as a result of the rapid evaporation of the solid in a confined space or, in some African lakes, it is released from decaying organic matter. Because it is denser than air, it may build up in low areas, eg, in caves. For a 15-minute exposure, the concentration in the atmosphere should not exceed 27,000 mg m^{-3}. About 0.04% is present in normal air, as compared with about 0.03% fifty years ago. This increase is a result of burning fossil fuels in motor vehicles, power stations, etc. This in turn is believed to be contributing to a very gradual rise in the temperature of the Earth (global warming) as a result of the greenhouse effect.
Carbon dioxide Solid 'dry ice'	COLD	It causes frostbite (burns) and needs careful handling. If it evaporates rapidly in a closed vessel, it may cause an explosion or, in a confined space, it may cause asphyxiation as the air is forced out.
Carbon monoxide Gas	TOXIC EXTREMELY FLAMMABLE	It is toxic if breathed in, with the danger of serious damage to health by prolonged exposure. It may cause harm to the unborn child. As little as 0.01% can cause headaches. The gas has no taste or smell. It is often formed when hydrocarbon fuels burn in a limited supply of air, eg, car engines especially in confined spaces, or gas-powered water heaters with poor ventilation. Every year, this causes many deaths in the home. Traces also occur in cigarette smoke and are implicated in heart and artery diseases. It also contributes to the greenhouse effect. For a 15-minute exposure, the concentration in the atmosphere should not exceed 232 mg m^{-3}. It forms explosive mixtures with air and oxygen. Mixtures with air between 12% and 74% carbon monoxide by volume are explosive.
Carbon Graphite, diamond, buckminsterfullerene	LOW HAZARD	Applies to lampblack, charcoal, activated carbon, decolourising charcoal. Soot is also mainly carbon but may be contaminated with carcinogenic chemicals. This was a cause of cancer amongst chimney sweeps in Victorian times. The hazards of buckminsterfullerene nanotubes are not fully known. Hot charcoal (carbon blocks), even if not glowing red, can slowly combust and stay hot for many hours.

Typical control measures to reduce risk

- Wear protective thermal gloves or use tongs for handling solid carbon dioxide.
- Use energy-efficient vehicles and power stations and/or non-fossil fuels to limit the amount of carbon dioxide or monoxide emitted.
- Use a ducted fume cupboard (**not** a recirculatory filter fume cupboard) for handling carbon monoxide.
- Have gas appliances serviced regularly.
- Use catalytic converters in car exhausts to reduce the amount of carbon monoxide released into the air.
- After use, allow hot charcoal blocks to cool in air; store them in air-tight metal containers.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Leak of gas from apparatus into the laboratory.
- ***How serious would it be if something did go wrong?***
  Eg, Global warming causing rising sea level and resultant flooding of low-lying areas.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **Solid in the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if solid carbon dioxide.
• **Solid on the skin or clothing**	Brush off quickly and immerse the affected area in cold water. If there are any signs of burning from solid carbon dioxide, call a doctor.
• **Vapour breathed in**	For carbon monoxide, or carbon dioxide in large quantities, remove the casualty to fresh air. Call a doctor if carbon monoxide was inhaled or if breathing is difficult.
• **Gas escape in a laboratory**	Open all windows. For large amounts of carbon monoxide, evacuate the laboratory.

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STUDENT SAFETY SHEETS 59

Hydrogen sulfide & other sulfides

including **carbon disulfide, ammonium, sodium, potassium, zinc, copper and iron sulfides**

Substance	Hazard	Comment
Hydrogen sulfide Gas	EXTREMELY VERY FLAMMABLE TOXIC	Mixtures of hydrogen sulfide with air containing between 4% and 45% hydrogen sulfide are explosive. It is very toxic if breathed in (more toxic than hydrogen cyanide). For a 15-minute exposure, the concentration of the gas in the atmosphere should not exceed 14 mg m^{-3}. In an average school laboratory, that level would be reached by the action of 200 cm^3. 1 M hydrochloric acid on excess sulfide. It has a very strong smell of rotten eggs and the human nose can detect as little as 0.01 mg m^{-3}, ie a drop or two 1 M hydrochloric acid on excess sulfide in an average school laboratory. At higher concentrations it anaesthetises (deadens) the sense of smell and so the danger may not be realised. It may sometimes be found in coal mines (*stinkdamp*) and is produced by rotting seaweed and is the commonest cause of death in sewer workers. Use of solutions of hydrogen sulfide or ammonium, potassium or sodium sulfides is safer than using the gas, although the gas will escape readily from the solutions, especially on warming.
Hydrogen sulfide Solution in water *(if 0.3 M or more)*	**TOXIC**	
Hydrogen sulfide Dilute solution in water *(if less than 0.3 M but 0.03 M or more)*	**HARMFUL**	
Hydrogen sulfide Very dilute solution in water *(if less than 0.03 M)*	**LOW HAZARD**	
Carbon disulfide Liquid	HIGHLY TOXIC FLAMMABLE	This is highly flammable and toxic. There is a danger of serious damage to health through prolonged exposure by inhalation. It may harm the unborn child and may impair fertility. It is irritating to eyes and skin. Use of this is not recommended in schools. The demonstration involving the reaction with nitrogen monoxide is very dangerous, especially if the oxide is not pure.
Sodium & potassium sulfide solid *or* solution *(if 0.4 M or more)* & **ammonium sulfide** solution *(if 0.7 M or more)*	**CORROSIVE**	Dilute acid reacts to produce hydrogen sulfide. The solids absorb moisture from the atmosphere, producing hydrogen sulfide. The solutions are strongly alkaline.
Sodium & potassium sulfide dilute solution *(if less than 0.4 M but 0.2 M or more)* & **ammonium sulfide** dilute solution *(if less than 0.7 M but 0.2 M or more)*	IRRITANT	
Sodium, potassium & ammonium sulfide very dilute solution *(if less than 0.2 M)*	**LOW HAZARD**	
Copper sulfide, copper pyrites, iron sulfide, iron pyrites, zinc sulfide solids	**LOW HAZARD**	These are insoluble in water. Dilute acid reacts to produce hydrogen sulfide. If heated strongly in air, may produce toxic sulfur dioxide (see *Sheet 52*) and the metal oxide. Iron pyrites is known as fool's gold.

Typical control measures to reduce risk

- If producing the gas in the lab, use the smallest amounts possible, eg no more than a few drops of acid on excess sulfide.
- Wear eye protection.
- Use a fume cupboard if adding more than a few drops of dilute acid to excess sulfide; ensure good laboratory ventilation and quickly dispose of solutions containing hydrogen sulfide.
- If smelling the gas, follow the safe technique: use your hand to waft the gas towards your nose.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, A leak of gas into the laboratory from apparatus or a warmed solution.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
Vapour breathed in	Remove the casualty to fresh air. Call a doctor if breathing is difficult.
Gas escape in a laboratory	Open all windows. If over 1 litre of gas is released, evacuate the laboratory.

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STUDENT SAFETY SHEETS 60

Ethanol

also applies to **Denatured alcohol and Methylated spirit**

Substance	Hazard	Comment
Ethanol Pure	HIGHLY FLAMMABLE	There is a serious risk of liquid catching fire; its vapour may catch fire above 13 °C. The vapour/air mixture is explosive (from 3.3 - 19% ethanol). Breathing vapour may result in sleepiness: the concentration in the air should not exceed 5760 mg m^{-3}.
Industrial denatured alcohol (IDA) [formerly **Industrial methylated spirit (IMS)**]	HIGHLY FLAMMABLE HARMFUL	It is more hazardous than pure ethanol because of the presence of 5% (v/v) methanol which is TOXIC. It is often used as a solvent, eg, for chlorophyll and for indicators, eg, Universal indicator, phenolphthalein and in chromatography.
Completely denatured alcohol (CDA)		It contains methanol, pyridine and a purple dye. CDA has a bad odour and is not suitable for use indoors.
Surgical spirit *(It contains small amounts of castor oil, methyl salicylate and diethyl phthalate)*	HIGHLY FLAMMABLE	It is suitable for demonstrating the cooling effect of evaporation. It can be applied to the skin on the back of the hand. It is used for medical purposes, eg, foot infections, cleaning the skin. It must not be swallowed.
Ethanol Dilute solution in water	LOW HAZARD	Alcoholic drinks contain ethanol, typically 3-7% (beers), 11-14% (wines), 30-40% (spirits). Although chemical hazards are low, there may be considerable effects on the body leading to a loss of judgement, slower reaction times, etc. Consumption is dangerous if driving a vehicle or operating machinery.

Typical control measures to reduce risk

- Use the smallest volume possible; wear eye protection.
- Make sure the room is well ventilated.
- Check that equipment for extinguishing fires is nearby, eg, damp cloth, bench mat, fire blanket.
- **Do *not* use near naked flames; if heating is necessary, use an electrically-heated water bath or hot water from a kettle.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Does ethanol need to be heated? Could quantities of the vapour be breathed in? Might there be practical jokes or fooling around? Are any reaction products hazardous?
- ***How serious would it be if something did go wrong?***
  NB Some of the most serious accidents in school science have involved ethanol fires, including clothing fires, and badly-burnt skin needing grafts.
- ***How can the risk(s) be controlled for this activity? Can it be done safely? Does the procedure need to be altered?***

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. NB: The casualty may show signs of drunkenness.
• **Spilt on the skin or clothing**	Remove contaminated clothing and rinse it. Wash the affected area and clothing with plenty of water.
• **Clothing catches fire**	Smother flames on clothing or the skin with a fire blanket or other material. Cool any burnt skin with gently-running tap water for 10 minutes.
• **Other ethanol fires**	Allow fires in sinks, etc to burn out. Fires at the top of test tubes, beakers, etc should be smothered with a damp cloth or heat-proof mat.
• **Spilt on the floor, bench, etc**	Extinguish all Bunsen-burner flames. Wipe up small amounts with a cloth and rinse it well. For larger amounts, open all windows, cover with mineral absorbent (eg, cat litter), scoop into a bucket and add water.

STUDENT SAFETY SHEETS 61

Propanone

also known as **Acetone**

Substance	Hazard	Comment
Propanone (acetone) Liquid Used as nail polish (varnish) remover [but ethyl ethanoate (ethyl acetate) is more usual].	HIGHLY FLAMMABLE IRRITANT	There is a serious risk of the liquid catching fire. Its vapour may catch fire above -20°C. It can cause severe eye damage and will degrease the skin. For a 15-minute exposure, the concentration in the atmosphere should not exceed 3620 mg m^{-3}. The smell can be detected by most people at about 47 mg m^{-3}, well below the level which could cause harm.

Typical control measures to reduce risk

- Wear eye protection.
- Make sure the room is well ventilated or, in a laboratory, use a fume cupboard if possible.
- Check ways of putting out any fires.
- **Do *not* use near naked flames; if heating is necessary, use an electrically-heated water bath or hot water from a kettle.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Does propanone need to be heated? Could there be high levels of vapour, perhaps as a result of chromatograms drying?
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

In the eye	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
Vapour breathed in	Remove the casualty to fresh air. Keep him/her warm. See a doctor if breathing is difficult.
Swallowed	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
Clothing catches fire	Smother flames on clothing or the skin with a fire blanket or other material. Cool any burnt skin with gently-running tap water for 10 minutes.
Other propanone fires	Allow fires in sinks, etc to burn out. Fires at the top of test tubes, beakers, etc should be smothered with a damp cloth or heat-proof mat.
Spilt on the skin or clothing	Remove contaminated clothing. If more than a test-tube amount was involved, wash the affected area and clothing with plenty of water.
Spilt on the floor, bench, etc	Put out all Bunsen-burner flames. Wipe up small amounts with a cloth and rinse it well. For larger amounts, open all windows, cover with mineral absorbent (eg, cat litter), scoop into a bucket and add water.

Chlorinated hydrocarbons

Substance	Hazard	Comment
Dichloromethane (Methylene dichloride)	HARMFUL	It is harmful if breathed in, with a possible risk of effects which cannot be reversed, eg, liver damage. Breathing high concentrations causes headaches. It degreases the skin. There is limited evidence of a carcinogenic effect. It is used in some paint strippers.
Trichloromethane (Chloroform)	HARMFUL	It is harmful, with a danger of serious damage to health by prolonged exposure through inhalation and if swallowed. There is limited evidence of a carcinogenic effect. It is irritating to the skin. It has been used as an anaesthetic.
Tetrachloromethane (Carbon tetrachloride)	TOXIC DANGEROUS FOR THE ENVIRONMENT	It is toxic if swallowed, from skin contact and if breathed in, with the danger of serious damage to health by prolonged exposure through inhalation. There is limited evidence of a carcinogenic effect. It damages the ozone layer and is harmful to aquatic organisms in the environment. It can no longer be legally bought and existing stocks should not be used in work with open test tubes.
1,1,1-trichloroethane (Methyl chloroform) and **Tetrachloroethene (Tetrachloroethylene)**	HARMFUL DANGEROUS FOR THE ENVIRONMENT	1,1,1-trichloroethane is harmful if breathed in. It damages the ozone layer. It damages the ozone layer. It can no longer be legally bought and existing stocks should not be used in work with open test tubes. There is limited evidence that tetrachloroethene is a carcinogen. It is toxic to aquatic organisms in the environment. It is used in dry cleaning.
Trichloroethene (Trichloroethylene)	TOXIC	It may cause cancer with possible risk of effects which cannot be reversed. It is irritating to the eyes & skin and its vapour may cause drowsiness and dizziness. It was used in dry cleaning but has been replaced by tetrachloroethene.

Typical control measures to reduce risk

- Use the smallest volume possible and wear suitable eye protection.
- Use a fume cupboard for anything larger than test-tube amounts; ensure good laboratory ventilation.
- When choosing a solvent, pick the safest one with suitable properties - cyclohexane, *Volasils* or *Lotoxane* are safer than chlorinated hydrocarbons and usually work satisfactorily.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if more than a 'sniff' is breathed in.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Wash the skin with soap and water. Take contaminated clothing outside for the solvent to evaporate.
• **Spilt on the floor, bench, etc**	**Open windows** if large amounts are spilt. **Consider the need to evacuate the laboratory for large spills of the more-hazardous solvents.** Cover with mineral absorbent (eg, cat litter) and scoop into a bucket. Add washing-up liquid and work into an emulsion. Wash to waste with plenty of water.

STUDENT SAFETY SHEETS 63

Hydrocarbons

Substance	Hazard	Comment
Methane (Natural gas) **Ethane** **Propane (Calor gas, camping gas)** **Butane (Lighter fuel)**	EXTREMELY FLAMMABLE	These gases form explosive mixtures with air and oxygen. Mixtures by volume of between 6% and 12% methane with air are explosive. Such mixtures may ignite below 650 °C. Butane is easily liquefied under pressure (it normally boils at 0 °C) and is denser than air.
Pentane, hexane, heptane **Petroleum spirits (ethers)** **Cyclohexane, cyclohexene** **Petrol (gasoline)** **Methylbenzene (Toluene)** **Dimethylbenzene (Xylene)**	EXTREMELY / HIGHLY FLAMMABLE HARMFUL	Hexane, petroleum ether (60-80 °C) and methylbenzene are harmful to health by prolonged exposure. For long-term exposure, the concentration in the air should not exceed 72 or 191 mg m^{-3}. Other hydrocarbons are harmful if inhaled or swallowed. Many are irritating to the skin and most have vapours that cause drowsiness/dizziness. Petrol should not be used in schools; see *Benzene* below. (Most except methylbenzene and dimethylbenzene are also DANGEROUS FOR THE ENVIRONMENT because they are toxic to aquatic organisms.)
Benzene and products containing more than 0.1% benzene	TOXIC / HIGHLY FLAMMABLE	Benzene causes cancer. There is a serious danger to health from breathing it in or from skin contact over the long term, or from swallowing it. Use of benzene or products containing more than 0.1% benzene is banned in all educational laboratories. This includes the use of unleaded petrol, which contains benzene.
Paraffin (Kerosene) **Diesel fuel** **Engine oil**	HARMFUL	Some oils may contain substances which cause cancer. After oil has been used in car engines, some parts may have degraded into more-hazardous products.
Naphthalene	HARMFUL	It is harmful if swallowed, with limited evidence of carcinogenic effects. It is used in moth balls. If heated, the concentration of the vapour in the air increases considerably. (It is also DANGEROUS FOR THE ENVIRONMENT because it is toxic to aquatic organisms.)

Typical control measures to reduce risk

- Use the smallest amount possible; wear eye protection; avoid skin contact; ensure the room is well ventilated.
- Use a fume cupboard or prevent escape of vapour, eg, with mineral-wool plugs in test tubes.
- Check gas supplies for leaks; store bottled gas in a cool place; use 'spirit burners' with care.
- Check that equipment to put out fires is nearby, eg, damp cloth, bench mat, fire blanket.
- **Do *not* use highly flammable liquids near naked flames; if heating is necessary, use an electrically-heated water bath or hot water from a kettle.**

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Do hydrocarbons need to be heated? Could quantities of the vapour be breathed in?
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Wash the affected area and clothing with plenty of water.
• **Clothing catches fire**	Smother flames on clothing or skin with a fire blanket or other material. Cool any burnt skin with gently-running tap water for 10 minutes.
• **Other fires**	Allow fires in sinks, etc to burn out. Fires at the top of test tubes, beakers, etc should be smothered with a damp cloth or heat-proof mat.
• **Spilt on the floor, bench, etc**	Put out all Bunsen-burner flames. Wipe up small amounts with a cloth and rinse it well. For larger amounts, open all windows, cover with mineral absorbent (eg, cat litter), scoop into a bucket and add water.

STUDENT SAFETY SHEETS 64

Carbohydrates

Substance	Hazard	Comment
Sucrose	LOW HAZARD	This is ordinary table sugar. It is cane sugar (also obtained from sugar beet). Acids formed by bacterial decomposition of sugar in the mouth cause tooth decay. Excess sugars in the diet, coupled with a lack of exercise, cause obesity and diabetes, leading to heart disease. Eating in laboratories is usually illegal under the *COSHH Regulations* because of the risk of contamination.
Glucose	LOW HAZARD	It is also known as dextrose. Acids formed by bacterial decomposition in the mouth cause tooth decay. Excess sugars in the diet, coupled with a lack of exercise, cause obesity and diabetes, leading to heart disease.
Fructose	LOW HAZARD	It is also known as laevulose or fruit sugar. Acids formed by bacterial decomposition in the mouth cause tooth decay. Excess sugars in the diet, coupled with a lack of exercise, cause obesity and diabetes, leading to heart disease.
Maltose	LOW HAZARD	It is also known as malt sugar.
Lactose	LOW HAZARD	It is also known as milk sugar.
Starch	LOW HAZARD	Starch is broken down by saliva and stomach acids into simple sugars.
Cellulose	LOW HAZARD	It is an approved food additive, E460. Cellulose is derived from the cell walls of fruit, vegetables and cereals. It is not digested. Dietary fibre (roughage) is an important part of the diet, helping prevent various diseases.
Food testing on carbohydrates		See *Student Safety Sheet 4.*

Typical control measures to reduce risk

- Wear eye protection when handling hazardous solids and solutions, eg, when food testing.
- Do not consume sugars or indeed any food or drink in laboratories; taste-testing investigations must be done outside laboratories unless scrupulous hygiene and no contamination can be ensured.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Small amounts of contaminants entering the mouth during taste-testing activities.
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Where? Does the procedure need to be altered? Should eye protection be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for 10 minutes. See a doctor if pain persists.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
• **Spilt on the floor, bench, etc**	Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.

Dyes & Indicators

Note: Many dyes and indicators are used in school science, in the home and in industry. This *Sheet* applies to those listed below, which include those likely to be found in schools. Be warned that some dyes are toxic and may cause cancer, some may contain hazardous impurities or are made up in hazardous solvents, many have not been well researched because they are not much used in industry and suppliers often vary in the hazard classifications they use.

Substance	Hazard	Comment
Congo red, Methyl orange	☠ TOXIC	Congo red is a carcinogen. Methyl orange is toxic if swallowed.
Dyes and **indicators,** solid, including: **Acridine orange, Alizarin red S, Aluminon, Aniline blue, Cresol red, Crystal violet (Methyl/Gentian violet), Direct red 23, Disperse yellow 3/7, Dithizone, Eosin, Eriochrome black (Solochrome black), Indigo, Magenta (Basic fuchsin), Malachite green, May-Grunwald stain, Methyl green, Methyl red, Methylene blue, Procion dyes, Resazurin, Rosaniline, Sudan I, II and IV, Xylene cyanol FF**.	✕ HARMFUL & / OR IRRITANT	Skin contamination will be very obvious. This should be avoided and dusts of most dyes can irritate the eyes and lungs while some may act as sensitisers. Dyes for use in the home (eg, *Dylon*) may be classed as IRRITANT. Dust from Procion dyes may be a sensitiser, but the M-X dyes present a greater risk than the H-E dyes.
Dyes and **indicators,** solid, including: **Acid blue 40, Alizarin, Blue dextran, Brilliant yellow, Bromocresol green, Bromophenol blue, Bromothymol blue, Carmine, DCPIP (PIDCP), Diazine green (Janus green B), Fluorescein (Dichlorofluorescein), Indigo carmine, Litmus, Methyl blue, Murexide, Neutral red, Nigrosin, Orcein, Phenol red, Phenolphthalein, Rhodizonic acid, Sudan black, Sudan III, Thymol blue, Thymolphthalein, Toluidine blue, Xylenol orange**.	LOW HAZARD	The substances listed here are not usually classified as hazardous but note the comments in the box at the top of the sheet. They should therefore be used with caution. Skin contamination should be avoided.
Dyes and **indicators** Dilute *aqueous* solutions of the above (except Congo red) which include **Full-range pH indicator, Screened methyl orange** and **Universal indicator**.	LOW HAZARD	Dyes & indicators in dilute solutions are unlikely to offer significant risk because most are less than 1% by mass. However, some are made up in solvents other than water and the hazards may be greater, eg, ethanol [HIGHLY FLAMMABLE if more than 25% (v/v)] or ethanoic acid which may be CORROSIVE.

Typical control measures to reduce risk

- Use the lowest concentration possible and wear eye protection for all but the most-dilute solutions.
- Reduce the risk of skin contact by wearing disposable gloves.
- Avoid powdered dyes & indicators escaping into the air; use a fume cupboard when handling the more hazardous ones.
- Avoid naked flames if using flammable solvents.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could dust from a dye or indicator be breathed in?
- ***How serious would it be if something did go wrong?***
  Eg, Would the problem be more serious than the skin being stained for a few days?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Dust breathed in**	Remove the casualty to fresh air. See a doctor if breathing is difficult.
• **Spilt on the skin or clothing**	Remove contaminated clothing. Wash off the skin with soap and plenty of water. Rinse contaminated clothing.
• **Spilt on the floor, bench, etc**	Scoop up solids (take care not to raise dust). Wipe up solution spills or any traces of solid with a damp cloth and rinse it well.

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STUDENT SAFETY SHEETS 80

Alkali metals

includes **Lithium, Sodium** *&* **Potassium**

Substance	Hazard	Comment
Lithium Solid	 HIGHLY FLAMMABLE  CORROSIVE	It reacts rapidly with water to produce hydrogen, an extremely flammable gas (see *Sheet 50*). Although difficult to ignite, once lit, it burns readily in air and is difficult to extinguish. It causes burns. Contact with moisture produces lithium hydroxide which is irritant to the skin and eyes. It reacts violently with many substances.
Sodium Solid		It reacts violently with water to produce hydrogen, an extremely flammable gas. It burns vigorously and is difficult to extinguish. It causes burns. Contact with moisture produces sodium hydroxide which is corrosive (see *Sheet 31*). It reacts violently with many substances.
Potassium Solid		It reacts very violently with water to produce hydrogen, an extremely flammable gas. It burns vigorously and is difficult to extinguish. It causes burns. Contact with moisture produces potassium hydroxide which is corrosive (see *Sheet 31*). It reacts violently with many substances. Over a period of years, it may develop a coating of yellow superoxide. Under slight pressure, eg, from a knife blade, this may explode.

Typical control measures to reduce risk

- Store alkali metals under liquid paraffin. Check potassium samples regularly for signs of yellowing.
- Handle sample using forceps, wear eye protection and use safety screens.
- Conduct all investigations on a small scale - generally use a rice grain-sized piece.
- Make sure everybody involved (eg, technicians clearing away) understands the hazards.
- Take steps to prevent theft.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could molten, corrosive metal spit out of a container?
- ***How serious would it be if something did go wrong?***
  NB There are occasional reports of pupils being taken to hospital (for treatment to cuts or as a result of chemical splashes) as a result of explosions of apparatus involving sodium.
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently-running tap water for at least 20 minutes. See a doctor. If it is necessary to go to hospital, continue washing the eye during the journey in an ambulance.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	Remove any pieces of solid with forceps. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Metal catches fire**	For sodium and potassium, smother with dry sand, anhydrous sodium carbonate or mineral absorbent (eg, cat litter). For lithium, smother with dry sodium chloride.
• **Spilt on the floor, bench, etc**	Scoop up as much metal as possible into a dry container. Cover the area with dry sand or anhydrous sodium carbonate (or, for lithium, sodium chloride) and scoop into a dry bucket for further treatment. Rinse the area with plenty of water and mop.

For further information, consult the latest edition of the CLEAPSS *Hazcards* or *Laboratory Handbook*

STUDENT SAFETY SHEETS 81

Group II metals

includes Magnesium *&* Calcium

Substance	Hazard	Comment
Magnesium Solid (ribbon, turnings, powder)	🔥 HIGHLY FLAMMABLE	It is moderately difficult to ignite but, once burning, it does so very vigorously and is difficult to extinguish. Ordinary fire-fighting methods are not suitable, but dry sand may be used. The flame is very bright and may damage eye sight. It reacts readily with acids to produce hydrogen, an extremely flammable gas. (See *Sheet 50.*)
Calcium Solid	🔥 HIGHLY FLAMMABLE	It reacts readily with water (or acids) to produce hydrogen, an extremely flammable gas. (See *Sheet 50.*) Contact with moisture forms calcium oxide or hydroxide which are IRRITANT to the eyes and skin. It is difficult to ignite but, once burning, does so vigorously.

Typical control measures to reduce risk

- Conduct all experiments on a small scale.
- Keep careful control of stocks to prevent theft.
- Wear eye protection and avoid looking directly at the flame from burning magnesium.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Is there the possibility of theft or foolish behaviour?
- ***How serious would it be if something did go wrong?***
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	If magnesium powder or calcium contaminate the eyes, flood with gently-running tap water for 10 minutes. See a doctor.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Skin burnt by burning metal or by moist calcium**	Remove any pieces of solid with forceps. Then drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor.
• **Burning metal fire**	Smother with dry sand.
• **Spilt on the floor, bench, etc**	Scoop up as much metal as possible into a dry container. Wipe the area with a damp cloth which (for calcium) should then be placed in a bucket of water.

Sulfur & Phosphorus

Substance	Hazard	Comment
Sulfur Solid	LOW HAZARD	Yellow crystals of sulfur occur in volcanic regions. In Victorian times, children were fed a mixture of brimstone (sulfur) and treacle, to do them good! Sulfur burns to form sulfur dioxide gas (TOXIC). See *Sheet 52*. Asthmatics are particularly vulnerable. When melting sulfur or heating it, eg, with iron, insert a plug of mineral wool in the mouth of the test tube to prevent sulfur vapour escaping and igniting.
Phosphorus (red) Solid	🔥 HIGHLY FLAMMABLE	It is highly flammable and explosive when mixed with oxidising substances. It has been used in some match heads.
Phosphorus (yellow / white) Solid	🔥 ☠ HIGHLY FLAMMABLE / VERY TOXIC	It is very toxic by inhalation and if swallowed. It has a long history of poisoning, eg, amongst workers using phosphorus to make matches. It causes severe burns. When handling it, have copper(II) sulfate(VI) solution available to remove specks on the skin, clothing, bench, etc. It catches fire spontaneously in air. It is used in incendiary bombs. When it burns, corrosive fumes are formed. Phosphorus fires are difficult to extinguish; smother with dry sand. It must be stored under water (or under an inert gas). When cutting phosphorus, do this under water, otherwise friction ignites it. It is hard to cut; do this in a strong container, eg, a mortar.

Typical control measures to reduce risk

- Wear eye protection when handling phosphorus or when heating or burning sulfur. Use small amounts.
- Avoid breathing fumes of sulfur dioxide, eg, use a fume cupboard or prevent sulfur vapour from igniting by using a mineral-wool plug in the mouth of a test tube.
- Wear protective gloves if handling yellow/white phosphorus; store and handle it in the absence of air.

Assessing the risks

- ***What are the details of the activity to be undertaken? What are the hazards?***
- ***What is the chance of something going wrong?***
  Eg, Could sulfur vapour form? Could it ignite?
- ***How serious would it be if something did go wrong?***
  Eg, Could people be exposed to sulfur dioxide gas?
- ***How can the risk(s) be controlled for this activity?***
  Eg, Can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

• **In the eye**	Flood the eye with gently running tap water for 10 minutes. See a doctor unless only a small amount of sulfur is involved.
• **Vapour breathed in**	Remove the casualty to fresh air. Call a doctor if breathing is even slightly affected.
• **Swallowed**	Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor.
• **Spilt on the skin or clothing**	For sulfur or red phosphorus, brush or wash off the solid. For yellow/white phosphorus, immerse in copper(II) sulfate(VI) solution for 15 minutes. Then drench the skin with plenty of water. See a doctor.
• **Spilt on the floor, bench, etc**	For sulfur or red phosphorus, brush up. For yellow/white phosphorus, cover with sand to prevent ignition. Soak in copper sulfate solution until there is no further reaction, then brush up.

Vocabulary

Aerosol	Very tiny droplets of liquid floating in a gas (usually air). Diseases are often spread by coughing and sneezing, which results in an aerosol containing microorganisms.
Allergy	Some people are allergic to particular substances. Their bodies' immune system reacts to these substances to an unusual extent, resulting in skin rashes, runny noses, wheezing or even shock.
Asthma	One type of allergy, which results in breathing difficulties.
Biohazard	May cause disease or harm in humans.
Carcinogen	A substance which may cause cancer, if breathed in, swallowed or absorbed via the skin.
Corrosive	A substance which may destroy living tissue, causing burns.
COSHH	*Control of Substances Hazardous to Health Regulations* which aim to limit the exposure of employees and others in the workplace to hazardous substances which may damage their health.
EHT	Extra High Tension. See HT.
Explosive	Substances that may explode as a result of heat, fire, friction or shock.
Eye protection	This includes safety spectacles, goggles and face shields. Goggles (or face shields) give better protection against chemical splashes and should always be used for anything classed as CORROSIVE or TOXIC.
Flammables	Substances which burn easily. There are three groups: EXTREMELY FLAMMABLE, HIGHLY FLAMMABLE and FLAMMABLE, depending on how easily a liquid vapourises.
Harmful	Similar to the effects of toxic substances, but larger quantities are needed to produce an effect.
HT	High Tension (high voltage); power packs used in schools may deliver more than 40 V at a current of more than 5 mA. These are **less** safe than EHT power packs, which have an output of up to 5 or 6 kV but the current is limited to 5 mA or less.
Ionising radiation	Radiation which, when absorbed by a substance, including living tissue, causes some of the molecules to turn into ions.
Irritant	A substance (including a dust) which behaves in a similar way to corrosives but, instead of destroying living tissue, causes significant inflammation (reddening) through immediate, prolonged or repeated contact with the skin or a mucous membrane (eg, eyes, lungs, etc).
M	Molarity - a way of measuring concentration. Also written as mol dm^{-3} or moles per litre. An ammonia solution which is 2 M has twice as many molecules of ammonia dissolved in the water than a solution which is 1 M.
mg m^{-3}	Concentrations of pollutant gases in air are sometimes measured as x milligrams of pollutant per cubic metre of air. An alternative unit is ppm, parts per million.
Mineral absorbent	When clearing up spills of chemicals it is often useful to soak them up on something inert (unreactive). Sand can be used, but other substances soak up more, eg, clay in the form of some types of grey 'cat litter' (familiar to those who keep cats as pets).
Mutagen	A substance which may cause genetic defects.
Oxidising agent	A substance which helps other substances to burn or explode.
Pathogen	An organism which causes disease.
Sensitising	A further exposure to a sensitising substance will produce an unusually severe reaction, even when the dose or the exposure time is less than the first exposure.
Toxic	A substance which, in very small quantities, may cause death or damage to health when breathed in, swallowed or absorbed via the skin.
Teratogen	A teratogen is any medication, chemical, infectious disease or environmental agent that might interfere with the normal development of a fetus and result in the loss of a pregnancy, a birth defect or a pregnancy complication.
v/v	A crude measure of concentration. A 10% v/v methanol solution contains 10 ml of methanol in 100 ml water.
w/v	A crude measure of concentration. A 10% w/v sodium chlorate(I) solution contains 10 grams of sodium chlorate(I) in 100 ml water.

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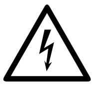
Safety signs & symbol letters

		T	**TOXIC**
		Xn	**HARMFUL**
		C	**CORROSIVE**
		Xi	**IRRITANT**
		E	**EXPLOSIVE**
		O	**OXIDISING**
		F+	**EXTREMELY FLAMMABLE**
		F	**HIGHLY FLAMMABLE**
	(No symbol required)		**FLAMMABLE**
		N	**DANGEROUS FOR THE ENVIRONMENT**
			**DANGER**

	**RISK OF ELECTRIC SHOCK**
	**IONISING RADIATION (RADIOACTIVE)**
	**NON-IONISING RADIATION**
	**LASER RADIATION**
	**COLD**
	**BIOHAZARD**
	**YOU MUST WEAR EYE PROTECTION**
	**YOU MUST WEAR PROTECTIVE GLOVES**
	**YOU MUST NOT HAVE NAKED FLAMES**
	**YOU MUST NOT DRINK THIS WATER**
	**YOU MUST NOT USE WATER ON FIRES**

Note: Symbols inside squares are to be used *only* on bottles and other containers.
Safety signs which are circular are **mandatory** (you MUST...) or **prohibitory** (you MUST NOT...).
Symbol letters (T, Xn etc) may be used in written documents but *not* on labels.

Colour code: Triangular signs have a *yellow* background; square ones an *orange* background; mandatory signs have a *white* pictogram on a *blue* background; prohibitory signs have a *black* pictogram on a *white* background, with *red* edging and diagonal line.

For further information, consult the latest edition of the CLEAPSS *Hazcards* or *Laboratory Handbook*

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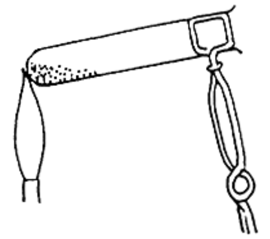
Heating things

Using a Bunsen burner

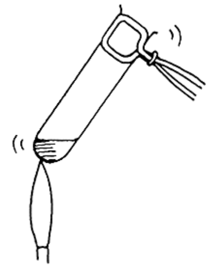
Type of flame	Gas tap	Air hole	Heat of flame	Appear-ance	Hazards	When used
Yellow flame	Fully (or partly) open	Closed	Warm		Flame coats objects with black soot.	To light the burner and when it is not heating anything. It is easy to see and will not readily set fire to clothing etc.
Gentle flame Pale lilac, smaller than medium flame	Partly closed	Partly closed	Very warm		It is difficult to see the flame in bright sunlight. Risk of blowing out.	If only gentle heat is needed.
Medium flame Yellow just disappears; pale lilac, almost invisible	Fully open	Partly closed	Quite hot		It is difficult to see the flame in bright sunlight. Some risk of blowing out.	For general heating. The flame is not too hot.
Roaring flame Inner cone blue, outer cone lilac	Fully open	Fully open	Very hot		It is difficult to see the flame in bright sunlight. Do **not** partly close the gas tap if the air hole is fully open.	If very strong heating is needed (which is not very often).

Heating solids in test tubes



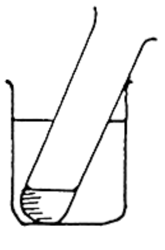
- Wear eye protection; do not normally have the test tube more than *one-fifth* full.
- If the solid is a powder, shake it so that it is sloped in the test tube.
- Using a suitable holder, keep the test tube pointing just up from the horizontal.
- Hold the test tube so that the bottom is just in the tip of the flame.
- Take care that the test tube is not pointing directly at anybody.
- Start with a gentle flame, increase to a medium flame and then a roaring flame, if necessary.

Heating liquids in test tubes



- Wear eye protection; use a wide-diameter test tube ('boiling tube').
- Do not normally have the test tube more than *one-tenth* full (it is much less likely to boil over).
- Add an anti-bumping granule ('boiling chip').
- For flammable liquids, you **must** use a hot-water bath (see below).
- Using a suitable holder, keep the test tube at an angle so that the bottom is just at the tip of the flame and the top is well clear of the flame.
- Start with a gentle flame and increase it only if necessary.
- Flick your wrist continuously *but gently,* so that the liquid is shaken.

Heating flammable liquids



- Wear eye protection; use a wide-diameter test tube ('boiling tube').
- Do not normally have the test tube more than *one-tenth* full (it is much less likely to boil over).
- Add an anti-bumping granule ('boiling chip').
- Do **not** heat directly over a naked flame. Instead, stand the test tube in a beaker of water. Hot water may be obtained from a hot tap or an electric kettle (or use an electric water bath). If necessary, boil the water in the beaker using a roaring flame; then extinguish the flame before the flammable liquid is put into the hot water.