ASSIST
AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEETS (AISs)

A compilation of AISs developed by Science ASSIST for Australian schools

Introduction

This compilation of ASSIST Information Sheets (AISs) has been created from the AISs posted on the Science ASSIST website prior to its closure in December 2021. They are grouped by their focus area and are hyperlinked from the contents page to enable easy navigation.

They have been compiled so that they can continue to be available to support schools after the closure of the Science ASSIST website in December 2021. Note: The AISs have not been revised since the date of publication in the footer, so many of the links to further information may no longer be current.

The AISs cover a wide range of topics and have been grouped broadly into laboratory management and procedures, laboratory equipment and laboratory notes for safe handling and preparation.

These ASSIST Information Sheets (AISs) were produced by the Science ASSIST project which was managed by the Australian Science Teachers Association (ASTA) in consultation with the Science Education Technicians Association (SETA).

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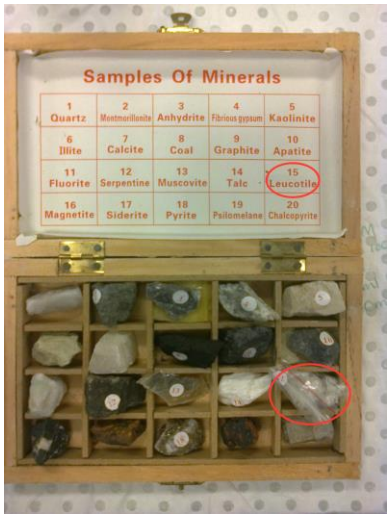
ASSIST INFORMATION SHEET:

Asbestos minerals in schools

Asbestos is not a single mineral, but is a collective name given to a number of very fibrous minerals. These are complex silicate minerals of magnesium and iron. Three different asbestos minerals are commonly referred to by colour – white, blue and brown asbestos. There are also some other associated minerals, which although not 'asbestos', have a somewhat similar fibrous nature and could be considered potentially hazardous. Very few of these are likely to appear in a school setting. There is also the possibility that some mineral specimens that are not asbestos could include some asbestos mineral content, though the risks of this are considered to be very low.

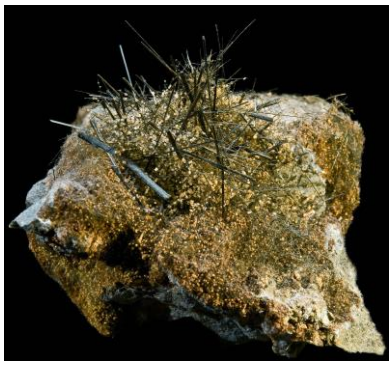
Science ASSIST has listed in the tables below the minerals that may possibly be found in school mineral kits.

Asbestos minerals

Name(s)	Appearance	Notes	Images
Chrysotile Also uncommonly known as **Leucotile** (A member of the Serpentine mineral group)	White/light coloured, as mineral specimens, usually obviously fibrous in appearance.	**White asbestos**. As the former most commonly used industrial asbestos mineral, it is responsible for most asbestos contamination issues. School science areas may have specimens of chrysotile that pre-date current health and safety knowledge. In recent years an imported mineral kit included specimens of Leucotile, which, apparently because of the obscure synonym, were not at first recognised as being asbestos. **Any chrysotile or leucotile specimens in schools should be removed as per instructions further in this document.**	 **1**  **2**

Crocidolite (The fibrous form of the Amphibole mineral Riebeckite)	Blue, silky lustrous fibrous mineral.	**Blue asbestos.** Though an uncommon mineral, it was commercially mined for many years in the WA town of Wittenoom. The former school specimen supply company Geological Specimen Supplies (GSS) used Crocidolite in some of their mineral kits, particularly the Lustre kit that demonstrated this mineral property. These kits date from the 1970s when crocidolite was being mined and used industrially, and before its health risks were fully known. Given the popularity of the GSS mineral kits, some schools will have these kits, though it is likely that they are no longer in use. **Any specimens of crocidolite should be removed, as per instructions further in this document.**	 3
Amosite (The very uncommon fibrous form of the Amphibole mineral, Grunerite)	Brown fibrous mineral.	**Brown asbestos**. Not commercially mined in Australia, and to the best knowledge of Science ASSIST, not supplied to Australian schools as mineral specimens. ASSIST believes that it is highly unlikely that schools will have specimens of this mineral. **Any specimens of amosite should be removed, as per instructions further in this document.**	 4

Other fibrous asbestos-like minerals

Name(s)	Appearance	Notes	Images
Actinolite **Tremolite** (A mineral series in the Amphibole mineral group)	Actinolite- dark green coloured fibrous mineral. Tremolite- white to grey fibrous mineral.	These two minerals belong to the same complex continuous silicate mineral series, and also belong to the larger collective Amphibole group. The semi-precious gem mineral, jade (nephrite) is a non-fibrous form of actinolite. Though uncommon, it is possible that some schools may have specimens of fibrous Actinolite. As this mineral is potentially harmful, and as it is not relevant to the Science curriculum, **any specimens of actinolite or tremolite should be removed, as per instructions further in this document.**	 5  6

Other fibrous minerals		There are some other fibrous minerals that are potentially hazardous. These include the fibrous mineral **Erionite**, a member of the larger Zeolite mineral group. Science ASSIST is not aware of any of these having been supplied to schools as teaching specimens. Their presence in schools is considered to be very unlikely. **Should such specimens raise concern, schools are advised to isolate the specimens in question by double bagging* and sealing them, pending further advice or removed as per instructions further in this document.**	

Rock and mineral specimens with potential asbestos contamination

Name(s)	Appearance	Notes	Images
Talc (mineral specimen)	A fine-grained white to pale green grey very soft mineral.	Talc is a magnesium silicate mineral, white to pale green grey in colour. It is the mineral with the designated hardness of 1 on Mohs Hardness scale. As such it has been a common item in school science for many decades, both as mineral specimens and as components of kits such as the older GSS Hardness kits, and the more recent versions of these from various other suppliers. Talc is a required mineral in the science curriculum. Geologically, it is possible for talc mineral specimens to include asbestos fibre contamination (e.g. actinolite). However, as educational talc specimens will have almost always come from commercial talc mines, and as commercial talc mining depends on an asbestos free product, the contamination of school talc specimens with asbestos fibres is considered to be very unlikely. Science ASSIST is currently aware of a number of Australian suppliers of talc specimens who can certify an asbestos free product. **Where schools are in doubt of the origin of their talc specimens, these can be double bagged* and sealed pending further advice or removed as per instructions further in this document.**	 **7**  **8**  **9**  **10**

Serpentine/ Serpentinite	Green soapy lustred rocks- sometimes called soapstone. The hydrated silicate minerals are serpentine; the resultant metamorphic rock rich in them is serpentinite.	Though not asbestos, it is possible that serpentinite can contain some asbestos fibres. This is not considered to pose a significant risk as school specimens of soapstone will be static and not subject to the generation of dust. The use of serpentine in a school science setting may be limited to earlier mineral property kits such as the GSS Lustre Kit, where it may demonstrate soapy or waxy lustre. Science ASSIST considers that this material has little if any current curriculum value, and therefore **specimens should be removed, as per instructions further in this document.**	 **11**  **12**

What is not asbestos?

Name(s)	Appearance	Notes	Images
Tiger Eye	Yellow semi precious gemstone with a fibrous texture, common in brooches, cuff links etc.	Silica after crocidolite: meaning that the original crocidolite mineral has been replaced by silica, so that all the original asbestos has gone, but the original fibrous structure of the blue asbestos is now preserved as silica. **This is NOT asbestos, and is considered safe.**	 **13**

Note: Various alerts on this issue have also listed the additional following terms: **anthophyllite, richterite** (amphibole minerals); **antigorite, lizardite** (serpentine minerals); **offretite** (a zeolite mineral) and **vermiculite** (a phyllosilicate mineral). Regarding vermiculite: although there is some evidence that there has previously been some contamination of vermiculite, current suppliers generally test for asbestos, so this does not appear to present a concern for recent (post 1990) supplies.

Science ASSIST considers that these are most unlikely to be occurring in school mineral samples. If in doubt, specimens can be double bagged* and sealed pending further advice.

Alerts have also listed ***amphibole*** and ***zeolite***. These are large mineral groups comprising many members, most of which are not fibrous, and are considered safe. It is more helpful to identify the specific varieties that may be fibrous and hazardous. These are noted in the tables above, for example ***Crocidolite*** (an amphibole), and ***Erionite*** (a zeolite).

The removal of geological samples of asbestos

Schools may have geological specimens of asbestos and/or specimens that potentially contain asbestos. Therefore, it is recommended that a review of all mineral kits and geological specimens be undertaken to assess for the presence of asbestos. Your school will need to make a judgement, in consultation with your state/territory workplace health and safety regulator, on how to proceed depending upon the contents and condition of your geological collection. Schools may be able to manage the risks at the school level or may need to arrange for specialist help. See Heads of Workplace Safety Authorities (HWSA) Imported Materials with Asbestos Working Group*, Health and safety alert - Asbestos in mineral kits,* November 2015, Asbestos Safety and Eradication Agency website, https://www.asbestossafety.gov.au/sites/asbestos/files/Safety_Alert_Asbestos_mineral_kits_9_November_2015.pdf

Managing the risks

Health risks associated with asbestos exposure relate to the inhalation (breathing in) of very fine fibres. If asbestos material is in good condition, is intact and has not been disturbed, it is unlikely to release asbestos fibres. Accordingly, any potential risk of exposure to asbestos is considered to be minimal.

For further information see **Appendix A**.

Science ASSIST recommends the following steps be taken:

1. **Immediately suspend all use** of any suspect kits or geological samples.
2. **Alert your school principal** and/or safety officer in the school regarding the need for a review of the school's geological samples to assess for the **possible** presence of asbestos.
3. **Undertake an audit of the geological specimens** in the school. This would include boxed rock and mineral kits as well as single specimens. Identify any specimens that either by name or by appearance could be asbestos, asbestos like, or could possibly contain asbestos. School staff should avoid disturbing dust or fibres by actions such as sweeping, dusting or vacuuming. Specialist help of a geologist may be required for identifying unlabelled specimens.
4. **Consult your school policy for dealing with asbestos.** Links to policies of government state/territory educational jurisdictions these are given in Appendix A.
5. **Consult your state/territory workplace health and safety regulator** regarding regulations and recommended processes for the removal and disposal of asbestos containing materials. Specialist assistance from a health and safety adviser may be appropriate.
6. **Ensure that future purchases** of rock and mineral specimens are from a supplier who is able to confirm that they **are asbestos free**, and document this instruction for any future acquisitions. Note: a number of suppliers are already providing this certification.

Get organised:

Before you start: see 'Key 'DOS and DON'TS' for handling asbestos materials', Department of Health website, http://www.health.gov.au/internet/publications/publishing.nsf/Content/asbestos-toc~asbestos-key-handle (6 March 2013).

- **Personnel:** Arrange for a competent person, who has the knowledge and skills to recognise and safely remove geological specimens of, or potentially containing asbestos.
- **Time:** Arrange sufficient time to do this when there will not be interruptions. This may best be done during the school holidays.
- **Place:** Perform the examination of rocks and minerals in an area which is easy to clean up, such as in a science laboratory with smooth bench tops and vinyl floors (i.e. not on carpeted floors)
- **Personal Protective Equipment (PPE):** The following will be required:
    - **Dust mask:** a dust mask, which is certified and labelled as conforming to the Australian Standard P1 or P2. These are available at hardware stores and safety suppliers. A general dust mask is not sufficient protection
    - **Safety glasses, disposable gloves and a disposable apron** are all recommended
- **Clean up items:** Have the following on hand.
    - Wet wipes/disposable cloths for wet wiping rocks and containers.
    - Spray bottle with some water and detergent for dampening down the rocks.
    - Heavy-duty plastic bags* for disposal: It is possible to purchase commercially produced heavy-duty bags* that are pre-labelled as asbestos waste from safety suppliers.
    - New plastic containers, such as fishing tackle boxes with individual compartments and a lid.

Kits containing known asbestos mineral specimens

Kits usually have a list of named items included, so this enables the relatively easy identification of the presence of asbestos minerals.

- **Option A: If your kit has been purchased recently**
  Do not disturb contents, double bag* the entire kit and contact your supplier. They may request a recall so follow their instructions accordingly and request a replacement kit that is certified to be asbestos free.
  If a recall is not provided follow option B.
- **Option B:**
  Do not disturb contents, double bag* and dispose** of the entire kit.

Kits containing mineral specimens potentially containing asbestos (e.g. talc, serpentine)

Talc and asbestos minerals can sometimes geologically occur together[1,2,3], and it is possible that talc specimens could potentially be contaminated with some asbestos fibres. However as the talc specimens that are supplied to schools probably will have come from commercial talc mines for 'cosmetic talc' where the product would need to be asbestos free, the risk of asbestos contamination from this source is considered to be very low. Whilst the possibility of this and the risk to staff and students is low, it cannot be discounted. Likewise it is possible for serpentine/ serpentinite specimens to include some asbestos.

- **Option A: If your kit has been purchased recently**
  Contact your supplier to confirm if it is asbestos free. They may request a recall so follow their instructions accordingly and request a replacement kit that is certified to be asbestos free.
  If a recall is not provided, follow option B or C
- **Option B:**
  If your school/regulator instructs you: double bag* and dispose** of the entire kit

- **Option C:**
  If your school/regulator permits this procedure: follow the instructions below for the removal of any talc or serpentine specimen and wet cleaning of the remainder of the kit.

Procedure for the removal of talc/serpentine and wet cleaning of kits (if permitted by your state/territory regulator)

1. Wear appropriate personal protective equipment (PPE) such as safety glasses, gloves, disposable apron and an Australian Standard dust mask marked P1 or P2.
2. Spray the kit or specimens with some soapy water to dampen any dust.
3. Remove any specimens of mineral talc or other suspect specimens from kits, which have not been confirmed as asbestos free and double bag* them for disposal**.
4. Wet wipe the remaining rock/mineral specimens in the kit/collection with wet wipes or disposable cloths. Dispose of used cloths as “asbestos waste” and double bag* them for disposal**. Note: specimens that are difficult to clean due to their shape and are not soluble in water may be submerged in water for cleaning and then this water can be flushed to waste.
5. Decide if the old container for the kit can be cleaned. If so then clean with soapy water. If not then dispose container as “asbestos waste” and double bag* them for disposal**.
6. Place ‘cleaned’ rocks/minerals in a new specimen container (such as a clear plastic fishing tackle box)
7. Dispose of all used PPE as ‘asbestos waste’ and double bag* it for disposal**. Wash safety glasses after use.
8. Ensure good laboratory hygiene and thoroughly wash your hands

Individual mineral specimens

Schools may have a collection of individual rock and mineral specimens, which possibly include asbestos and other specimens potentially containing asbestos (e.g. serpentine, talc). These may not be identified/labelled and could be stored loose in cupboards, drawers or boxes and may be very dusty due to years of sitting undisturbed.

Schools may need to request assistance from a geologist and/or a health and safety advisor in managing the identification of samples, assessing the risk of any possible contamination, and addressing the clean-up.

*Double bag: seal specimens in two sturdy plastic bags which are a minimum of 0.2mm thickness and labelled as required in the ‘Model Code of Practice - How to Safely Remove Asbestos’ (Note: ordinary zip-lock bags are not sufficiently thick), or place all items for disposal in a commercially produced heavy-duty plastic bag, which is sealed and pre-labelled with ‘Caution Asbestos waste – do not inhale dust’

**** Note: All asbestos waste should be taken to an asbestos disposal facility**. Your nearest facility can be located using the online tool on the Asbestos Safety and Eradication Agency (ASEA) website: http://asbestossafety.gov.au/search-disposal-facilities

Image references

1. **Chrysotile** (white asbestos) also known as Leucotile. Stock photo.
2. Example of a kit containing Leucotile stored in a zip lock bag. (Reproduced with permission Qld DETE 2014)
3. **Crocidolite** (blue asbestos), variety of Riebeckite - Locality: Pomfret Mine, Vryburg - Exposed in the Mineralogical Museum, Bonn, Germany. © Raimond Spekking (own work) CC BY-SA 4.0 (via Wikimedia Commons) https://en.wikipedia.org/wiki/Riebeckite#/media/File:Krokydolith_-_Mineralogisches_Museum_Bonn_(7385).jpg
4. **Amosite** (fibrous grunerite), South Dakota. Public domain. https://en.wikipedia.org/wiki/Grunerite
5. **Actinolite** (acicular form) with calcite, Portugal. Didier Descouens (own work) CC BY-SA 4.0 (via Wikimedia Commons). https://commons.wikimedia.org/wiki/File:ActinolitePortugual.jpg
6. **Tremolite**, France. Didier Descouens (own work) CC BY-SA 4.0 (via Wikimedia Commons). https://commons.wikimedia.org/wiki/File:Tr%C3%A9molite-Bar%C3%A8ge.jpg
7. **Talc**. Small piece of the hydrated magnesium silicate mineral. Stock photo.
8. **Talc**, Vermont, USA. Flikr, sdixclifford CC BY 2.0 https://www.flickr.com/photos/30486689@N08/3561500792
9. **Talc**. Deer Lake Peridotite. Flikr, James St. John CC BY 2.0 https://www.flickr.com/photos/jsjgeology/8281241057
10. **Talc** rock, Texas, USA. Flikr, James St. John CC BY 2.0 https://www.flickr.com/photos/jsjgeology/15068551025
11. **Serpentinite**, Vermont, USA. Flikr, James St. John CC BY 2.0 https://www.flickr.com/photos/47445767@N05/16940796272/
12. **Serpentinite**, Michigan, USA. Flikr, James St. John CC BY 2.0 https://www.flickr.com/photos/47445767@N05/16755884589/
13. **Tiger Eye**. © Peter Turnbull. Reproduced with permission.

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[1] AIOH. 2008. *AIOH Position Paper on Asbestos.* Victoria, Australia. http://www.aioh.org.au/downloads/documents/PositionPapers/AIOH_AsbestosPositionPaper.pdf

[2] 'Talc powder' mesothelioma.com website. http://www.mesothelioma.com/asbestos-exposure/products/talc-powder/ (Accessed 25/09/2015)

[3] IARC. Monograph. Asbestos http://monographs.iarc.fr/ENG/Monographs/vol100C/mono100C-11.pdf

Appendix A

Useful websites

Asbestos safety and eradication agency website https://www.asbestossafety.gov.au/

'Key 'DOS and DON'TS' for handling asbestos materials', Department of Health website, http://www.health.gov.au/internet/publications/publishing.nsf/Content/asbestos-toc~asbestos-key-handle (6 March 2013)

Model codes of practice:

'Model Code of Practice - How to Safely Remove Asbestos' Safe Work Australia website, http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/safely-remove-asbestos-cop (23 December 2013)

'Model Code of Practice - How to Manage and Control Asbestos in the Workplace', Safe Work Australia website, http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/manage-control-asbestos-cop (7 December 2011)

Education Department safety management plans/procedures

Science ASSIST provides these links as a service. Please check with your educational authority that you are accessing the latest version.

ACT: Chief Minister, Treasury and Economic Development Directorate, 2010. *ACT Asbestos Management Review – 2010*, ACT CMD website http://www.cmd.act.gov.au/__data/assets/pdf_file/0011/235991/asbestosreview.pdf (1 September 2010)

New South Wales: NSW Department of Education and Training, 2008. *Asbestos Management Plan Asset Management Directorate,* NSW DET website, https://www.det.nsw.edu.au/media/documents/about-us/supplying-to-us/asbestos-register/asbestosmanplan.pdf (September 2008)

Northern Territory: Northern Territory Government *Asbestos Alert. Stop. Think Asbestos. Seek Advice. Information for schools*, NT DET website http://www.education.nt.gov.au/__data/assets/pdf_file/0008/11141/AsbestosSchoolHandbook.pdf (Accessed November 2015)

Queensland: 'Asbestos management in department-owned facilities', Education Queensland website http://education.qld.gov.au/asbestos/ (4 March 2015)

South Australia: South Australian Department for Education and Child Development, 2012. *Asbestos Management Procedure*, DECD website http://www.decd.sa.gov.au/docs/documents/1/Asbestos_Management_Proce.pdf (March 2014)

Tasmania: Tasmanian Department of Education, 2014. *Asbestos Management Plan,* DoE website, https://www.education.tas.gov.au/documentcentre/Documents/Asbestos-Management-Plan-July-2014.pdf (1 July 2014)

Victoria: Victorian Department of Education and Training, 2015. *School Asbestos Management Plan.* Template. DET website, http://www.education.vic.gov.au/Documents/school/principals/management/asbestosmgtplan.docx (June 2015)

Western Australia: 'Management of Asbestos Containing Materials in Schools and Other Workplaces' WA Department of Education website, http://det.wa.edu.au/policies/detcms/policy-planning-and-accountability/policies-framework/policies/management-of-asbestos-containing-materials-in-schools-and-other-workplaces.en?cat-id=3458001 (1 August 2007)

History of reviews

Date	Version Number	Notes
16 Nov 2015	Version 1.0	
17 Nov 2015	Version 1.1	Hyperlink added to the tables to direct the reader to instructions for removal of specimens further in the document.
20 Nov 2015	Version 1.2	p4 Amended note on Serpentine to remove all specimens p7 Added step 8 good laboratory hygiene p7 Added detail for thickness of plastic bag

ASSIST INFORMATION SHEET:

Footwear in school science laboratories

It is important that schools have a set of 'Laboratory rules' established for the school science department, which apply to all people entering the science laboratory including students, teachers and technicians. These rules should include required Personal Protective Equipment (PPE) that includes appropriate footwear.

Footwear that provides good protection for students and staff in school science laboratories is recommended. This is closed in shoes with leather uppers that cover the top of the foot and sturdy non-slip soles. Sandals, court shoes, open toe shoes, thongs, mesh, open weave or canvas shoes do not provide sufficient protection from hot or corrosive liquids or from broken glass.

A school science laboratory should develop safety management systems by identifying the hazards and assessing and managing the risks in the same way as in other laboratories such as in universities or industry. The level of protection required is dependent upon the nature of the activity and subject to a risk assessment.

There are many hazards in the laboratory to be considered when determining appropriate footwear, for example: slippery floors, chemical spills or falling objects. The aim of protective footwear is to protect the wearer from injuries incurred such as resulting from slipping on slippery floors; impact from falling objects or contamination from chemical spills.

It is suggested that the 'Laboratory rules' established for the school are displayed on each laboratory door, which includes the requirements for appropriate footwear. Some schools also display a poster of examples of acceptable and unacceptable laboratory footwear, such as the one included on the front page of this information sheet.[1]

The following link also provides some good photographs of examples of appropriate and inappropriate laboratory footwear.

Electron Microscope Unit, Mark Wainwright Analytical Centre 'Lab footwear guide', UNSW website http://srv.emunit.unsw.edu.au/pdfs/Lab%20footwear%20guide.pdf (Accessed November 2014)

This information is based upon the following excerpts from AS/NZS 2243.1:2005 *Safety in laboratories Part 1: Planning and operational aspects*[2]:

> 3.1 LABORATORY SAFETY MANAGEMENT SYSTEMS
>
> 3.1.1 General
>
> To manage occupational health and safety in a laboratory, laboratory safety systems shall be implemented.
>
> 3.1.3.5 Safety equipment
>
> (b) Requirements for clothing, apparel (e.g. jewellery), hairstyles and footwear worn by laboratory personnel compatible with safe working practices shall be prepared and implemented.
>
> 4.1 REQUIREMENTS FOR SAFE CONDUCT
>
> Safety in the laboratory depends upon personnel achieving a recognized standard of behaviour. Personnel who have medical conditions that can affect their ability to work safely within the laboratory's procedures, or that can contribute to increasing the hazardous nature of the situation should report this to the appropriate person. The following requirements shall apply to all personnel who use or enter the laboratory:
>
> (c) Ensure that personal clothing is suitable to laboratory conditions, e.g. non-slip, closed-in footwear. Do not wear open-toed shoes in the laboratory.
>
> 4.2 USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE)
>
> 4.2.1 General
>
> Minimum requirements for PPE in a laboratory shall be laboratory clothing (see
>
> Clause 4.2.2), protective eyewear and closed shoes unless lesser requirements can be justified by a risk assessment.
>
> 4.2.6 Safety footwear
>
> Where specific safety footwear is required for a particular hazard, it shall be selected in accordance with AS/NZS 2210.

[1] Source unknown

[2] These extracts are from AS/NZS 2243.2005 Safety in laboratories Part 1: 'Planning and operational aspects' reproduced with permission from SAI Global Ltd under Licence 1407-c117

ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEET:

Guidelines for ordering, distribution and return of equipment for practical activities

The purpose of the school science preparation room is the preparation of equipment and chemical solutions required for science practical classes. Regulation of the request, supply and return of practical resources by the laboratory technician maintains efficiency and best scientific practice in the preparation room. In many school science laboratories, the role of the technician is to provide all the materials required for a practical activity in a safe and timely manner.

Setting procedures and protocols for the ordering, distribution and return of practical activities should be a consultative process between the teacher in charge of science and the technician. The technician should have a good understanding of the curriculum and the practical activities required, the equipment available, and the time they need to prepare resources and chemical solutions.

Ordering practical activities

All requests from teachers for laboratory equipment, chemicals and materials should always be in writing and include chemical concentrations and volumes, and equipment quantities.

The technician needs to know:

- which teacher is making the request, and if the teacher has completed a risk assessment for the activity
- in which laboratory the practical activity is to be carried out
- the day and lesson for the practical activity
- the year group and class (and sometimes ability)
- a reference to the written practical activity, usually in a unit of work. Alternatively, a clear list of equipment and other resources is required
- that relevant details are clearly stated, e.g., the concentration of solutions required, or which experiment will be performed
- whether the materials are for a class practical, with the number of sets required, or are for a demonstration or round robin
- if the experiment is to be repeated with another class
- of any health and safety information, where appropriate
- if any worksheets or other resources are needed to accompany the practical activity.

New technicians, especially those who work alone, will need clear and detailed lists of equipment, together with information on the procedures for preparing practical activities including those activities commonly requested.

Bookings of practical activities may occur online via a commercial booking program, a commercial risk assessment program, internal electronic systems or by email. Alternatively, booking can be written on a booking form, written into a table (see Supplementary Information at the end of this document) or on a display board in the preparation room. The advantage of using online systems is that a permanent record can be kept of particular practicals requested for a class, and practical

procedures and risk assessments can be electronically attached to the booking. Online booking systems also enable teachers to book practical activities several weeks in advance, depending on the electronic system used.

Timeframe for booking practical activities

The technician should be involved in discussions when setting timeframes for science practical activity bookings. The agreed timeframe should be written into departmental policy and used with the school's risk assessments for technician activities. If systems are not in place for managing the whole process or are not adhered to, the technician's job will be constantly under pressure, disorganised and potentially hazardous, and the science teachers may not have their practical resources carefully prepared or in place when they need them.

As part of their induction, the teacher in charge of science should ensure that new science teachers or trainee teachers are informed about the systems in place for requesting resources for practical activities in the department and why it is important to conform and follow these systems correctly. It is not recommended to leave practical activities as lessons for relief teachers to conduct.

Technicians should also be given the opportunity and time to participate in this induction process and inform new science teachers about the systems in use in their preparation rooms. This would include the practical activity booking system, i.e. what documents are used, and the amount of notice required.

Considerations for establishing a practical activity booking timeframe include:

- the size of the school student population
- the number of science classes, laboratories and how many practical classes are running at any one time
- the number of student groups per class
- the number of buildings in which science laboratories are located within the school
- the number of laboratory technicians and the hours worked
- the knowledge and experience of the laboratory technician
- other duties required of the laboratory technician either within the science faculty, or other school departments
- the number of resources available
- the complexity of requirements and whether this is an established or new activity that may need to be trialled beforehand
- whether there are sufficient resources and storage for a practical activity to be prepared permanently and kept in a tote box for subsequent classes to use.

Guidelines for timeframes

Many technicians are able to prepare resources for a junior practical activity within 1–2 working days, depending on the complexity of the request. This is a recommended timeframe. Exceptions may include the allowance of extra time to purchase grocery items or dissection materials, for new and inexperienced technicians and to prepare solutions of hazardous chemicals so as not to compromise the health and safety of the staff. Significant time may also need to be allocated to trial new activities to ensure their suitability for the school laboratory setting.

Many practical activities for primary science and junior secondary school programs can be prepared and stored in tote boxes well in advance, with the exception of chemical solutions and

items that require refrigeration or freezing. It also may not be practical to include items that are used widely in activities such as stopwatches or awkward items such as metre rulers. However if equipment supplies and storage facilities allow, the use of tote boxes allows the technician to quickly prepare a practical activity for teachers. Since senior practical activities often require more preparation, having junior practicals pre-prepared enables technicians to commit extra time to prepare senior resources.

A reasonable time frame for senior practical bookings can be up to 3 days. This enables technicians to precisely prepare chemical solutions, particularly for titrations, and to prepare more complex practical activities where a longer time allocation is required.

Risk assessments should be completed by the laboratory technician before undertaking tasks in the prep room. Many schools employ only one laboratory technician. Work carried out in isolation can be hazardous, particularly for an inexperienced technician. Laboratory technicians should be aware of and use PPE, be aware of accident and emergency procedures, manual handling and chemical handling procedures. A laboratory technician working alone should notify another reliable person when they are working with hazardous materials or are away from the prep room, such as in a remote chemical store room.

Science departments should have good resources such as internet access and textbooks, where the technician can look up details of practical activities. New technicians should be encouraged to ask more experienced technicians or teachers for assistance with procedures and experiments with which they are not familiar.

Equipment usage clashes can be avoided when using an online system that does not allow multiple bookings of the same equipment. Clashes can be avoided when using manual booking systems such as a hardcopy diary by visually checking the activity requests and then liaising with the relevant staff members to achieve a fair outcome.

Practical bookings made outside of the department timeframe should always be followed up by the teacher consulting with the technician to ensure the resources will be available at the day and time requested and to ensure the technician has the time and resources to prepare for the activity. Ideally, teachers can contribute to this efficiency by conforming to practical booking guidelines. A consistent time frame should be set for all or most practical activity bookings.

Organising practicals

Steps required to prepare for a practical activity.

1. Ensure risk assessments are complete. Science ASSIST recommends that the person who has the best knowledge of the particular risks should carry out the risk assessment; generally within a classroom this is the classroom teacher, and in the preparation room, this would be the science technician. However, there may be times when a collaborative approach is more appropriate. When the risk assessment has been completed then preparation may continue.
2. Read the practical method, making notes of the quantities of equipment, chemicals, the solutions required, and the concentrations of solutions. Consider if subsequent classes will require the activity.
3. Prepare and calibrate equipment. Ensure equipment is clean, and all users are trained on usage. Ensure there is a Standard Operating Procedure included with the equipment.
4. Prepare chemical solutions. Print labels and attach securely to containers with the appropriate GHS label (see *AIS: Labels for school science chemicals*). Calculate concentrations and volumes required. Accurately prepare solution and aliquot into class sets.

5. Defrost items stored in the freezer, if required.
6. On the day of the practical activity, double check that all resources are in a tote box or utility tray including the items stored in the refrigerator. Be aware of items that need to be delivered at room temperature, or kept cool on ice.
7. For each class using the same practical activity, tag the tote box or utility tray with the teacher's name and other necessary information, such as day and time of activity and if another class will require the activity. Store the tote box in the central pickup area for collection by the class teacher.

Distribution and return of equipment for practical activities

The procedure for the distribution and return of equipment for practical activities should be established through consultation between the teacher in charge of science and the technician. Each school needs to determine who is responsible for delivering the equipment to the laboratories and back to the preparation room. Students are not permitted into preparation rooms unless accompanied by a teacher, and should not be sent to the preparation room to collect hazardous chemicals or expensive equipment. In larger schools, and where teaching laboratories are spread across two or more buildings, or on different levels, technicians may not be able to deliver the equipment to teaching laboratories.

Teachers should be responsible for the tote box and its contents. They need to allow sufficient time during their lesson to ensure that items are counted out and counted in. After the activity, correct waste disposal is carried out, glassware should be rinsed with tap water by students, then checked by the teacher and packed into the tote box before returning to the prep room. This enables the practical activity to be used again by another class. Students should clean the laboratory bench with an appropriate cleaning agent and ensure the laboratory is tidy after practical activities.

Upon return to the prep room, the tote box should be checked by the technician for glassware breakages and missing items. If the activity is to be used by a subsequent class, the technician should ensure that the correct number of items are present, any glassware is clean and not chipped or cracked, chemical solution container labels are legible and undamaged, and the quantity of chemical solutions or equipment is sufficient.

Any faulty equipment must be returned to the preparation room accompanied with written details identifying the equipment as faulty and the nature of the fault.

All equipment and chemicals must be returned to the preparation room by teachers when they are not in use.

Experiments that are required to be left for a few hours or days should be returned to the preparation room with an 'experiment in progress' sign indicating who owns the experiment, what chemicals are present and the time the experiment will finish. A current Safety Data Sheet should accompany activities using chemicals.

It is expected that these guidelines may be implemented with some flexibility as appropriate for the individual technician. Some teachers may require more assistance for various reasons. However, technicians should be aware of their own job description, and not be responsible for classroom control of students where a teacher should be in charge. Technicians should be mindful of being fair to all teachers in the provision of technical services directly to classes. Periodically, it may be beneficial for a technician to demonstrate a particular method or procedure to a class, or assist students during class time or during science field work. This is an individual issue between technicians and teachers, and the school.

Procedure for accessing equipment when the technician is not present

Teachers who need to collect additional materials from the prep room when the technician is not present are encouraged to notify the technician as soon as possible. A note left for the technician is good manners and always appreciated. Other teachers looking for these additional resources for the same lesson may be inconvenienced if the technician is not aware of the immediate location of the materials. Chemicals are generally not available to teachers if no technician is present due to the requirement that chemicals be stored in a secure area.

As school student populations grow and the number of science classes increase, consideration should be given to laboratory technician staffing levels and/or the daily tasks of technicians. Scrutiny of the job descriptions of technicians ensures they maintain efficiency in the prep room by ensuring practical activities booked are prepared on time for the class. Technicians should be mindful of performing duties outside their job description where their core role is compromised. Maintaining practical booking timelines will ensure all teachers and ultimately students will have their booked practical prepared on time, with precision and accuracy. Technicians should ensure they adhere to their job descriptions to ensure this core business is maintained with no compromise on best scientific practice. A service factor for the allocation of adequate staffing hours for technicians is discussed in the report *The Status of School Science Laboratory Technicians in Australian Secondary Schools* prepared by Professor Mark Hackling as well as in the *School Science Laboratory Technicians National Standards 2013*.

Presenting practical activities to students is a team effort by the technician and teacher. At times unforeseen circumstances may arise that alter the scheduling of activities. It is important that good communication channels are established to minimise the disruption to all parties involved and ensure the harmonious facilitation of the request, supply and return of equipment for practical activities.

References

CLEAPSS. 2006. *Running a Prep Room* http://www.cleapss.org.uk (Subscription required. Accessed December 2014)

CLEAPSS. 2006. *Running a Prep Room Documents* http://www.cleapss.org.uk (Subscription required. Accessed December 2014)

Hackling, M. 2009. *The Status of School Science Laboratory Technicians in Australian Secondary Schools.* Edith Cowan University. Perth Western Australia. See http://moodle.asta.edu.au/mod/resource/view.php?id=598

Science Education Technicians Australia.2013. School Science Laboratory Technicians National Standards 2013 http://moodle.asta.edu.au/mod/resource/view.php?id=2526

SUPPLEMENTARY INFORMATION:

Figure 1: Example of a science equipment order form:

Science Equipment Order Form Term: _____ Week: _____

Date Required: __/__/____ Room: ____ Teacher: _____ Year Group: _____

Day:	Monday	Tuesday	Wednesday	Thursday	Friday	Demo:	
Period:	1	2	3	4	5	No. Groups	

RISK ASSESSMENT COMPLETE: Y/N Have safer methods, safer or less concentrated chemicals, or a demonstration been considered?

EQUIPMENT: Include quantities and Standard Operating Procedures.

CHEMICALS: Solid/solution. Include concentration, volumes and relevant Safety Data Sheets.

Laboratory Manager Notes and Comments (attach sheet if required):

Science Equipment Order Form Term: _____ Week: _____

Date Required: __/__/____ Room: ____ Teacher: _____ Year Group: _____

Day:	Monday	Tuesday	Wednesday	Thursday	Friday	Demo:	
Period:	1	2	3	4	5	No. Groups	

RISK ASSESSMENT COMPLETE: Y/N Have safer methods, safer or less concentrated chemicals, or a demonstration been considered?

EQUIPMENT: Include quantities and Standard Operating Procedures.

CHEMICALS: Solid/solution. Include concentration, volumes and relevant Safety Data Sheets.

Laboratory Manager Notes and Comments (attach sheet if required):

Table 1: Suggested practical activity booking template

	MONDAY *1/12/14*	**TUESDAY** *2/12/14*	**WEDNESDAY** *3/12/14*	**THURSDAY** *4/12/14*	**FRIDAY** *5/12/14*
Period 1	*Mrs Jones Yr 7 Bunsen burners Lab 4* *Mr Smith Yr 8 Rock Identification Lab 2*				
Period 2			*Miss Kennedy Yr 9 Flame tests Lab 1*		
Period 3				*Mr See Yr 11 Chem Exp 14 Lab 3*	
Period 4					
Period 5					

ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEET:

Lab glass and porcelain disposal – the 'sharp end' to disposing of broken glass and porcelain.

What is best practice for disposing of broken glass or porcelain in the laboratory? Should you wrap it before placing it in the bin? Is it a good idea to place it with general waste? What is the best practice and a safe way to dispose of broken or redundant lab glass?

Borosilicate, soda glass and porcelain laboratory equipment is inherently prone to breakage, chipping or cracking. A risk assessment will establish if glassware items can be substituted for plastic or other less fragile materials. If elimination or substitution is not possible, damaged or broken items should be replaced as soon as practicable and breakages disposed of with consideration to the following aspects.

For the purpose of this information sheet, fragile items such as mortar and pestles, evaporating basins, soda glass, Pasteur pipettes and microscope slides are referred to as glassware.

Safety and handling considerations

It is not advisable to use broken or chipped glassware in the laboratory and damaged items should be replaced as soon as practicable. It is preferable that an adult handle broken glass with consideration to a risk assessment for handling broken glassware.

Warn others that broken glass is in the area, cordon off the area and attend to any first aid required ensuring any resulting injuries are reported.

To minimise the risk of skin penetration or eye injuries, suitable PPE should be worn, such as safety glasses, lab coat, covered shoes and leather gloves.

Assess the risk of retrieving the broken glass – if it is in large pieces or several small pieces, should it be swept up or picked up with forceps? Are there hazardous liquids or solids associated with the broken glass? If so, consult the SDS for clean-up procedures before retrieving the glass.

Clean broken glass is laboratory glassware that is not contaminated with any biological or infectious material (human or animal blood; body fluids, parts or materials; microbiological materials), toxic, recombinant or radioactive substances or chemicals.

Ensure all labels and lids are removed prior to disposal.

Clean, broken glass may be collected into a dedicated, rigid and impenetrable container or bin that is clearly labelled 'Clean Broken Glass'[1]. Items should be placed **directly** into the bin, not passed hand to hand, wrapped or placed into a garbage bag.

Contaminated broken glass should be dealt with in the following manner:

- Small items (e.g. beaker < 500 ml) should be placed in sharps containers for collection and disposal by an approved contaminated waste contractor.
- Large items of broken glassware should be decontaminated before disposal.

- If contaminated with chemicals, safely extract fumes from glassware overnight in a fume cupboard and decontaminate appropriately. All labels and lids should be removed before placing into a 'Clean Broken Glass' receptacle for disposal into an industrial waste bin.
- **Glassware contaminated with hazardous materials, which cannot be decontaminated, should be disposed of as hazardous waste.**
- If contaminated with biological products or infectious materials, items should be autoclaved or disinfected to remove any contamination. All labels and lids should be removed before placing into a 'Clean Broken Glass' receptacle for disposal into an industrial waste bin.

In the event that contaminated broken glass becomes embedded in skin, a piece of the same glassware should be retained for comparison tests by a hospital.

UNDER NO CIRCUMSTANCES SHOULD THE CONTENTS OF SHARPS CONTAINERS (containing items such as scalpel blades) BE EMPTIED INTO GENERAL GARBAGE BINS OR INDUSTRIAL WASTE BINS, NOR BE EMPTIED and RE-USED[2].

Environmental considerations

Laboratory glass is not suitable for recycling[3] as there may have been exposure to unknown contaminants such as chemicals or biological samples. When disposing of any broken glass ensure any contamination hazard is taken into account before disposal[4]. Contaminated items should be treated prior to disposal, if it is possible to do so, or segregated into a separate suitable disposal receptacle if applicable. Segregation is on the basis of the primary hazard. If secondary hazards are present, then persons handling glass waste need to make an assessment as to whether further segregation is required in order to ensure that any secondary hazards associated with handling the waste are properly identified and controlled[5].

School and local authority considerations

Processes within local government waste transfer stations differ between establishments and jurisdictions. Consult your state education authority and local government waste department for specific procedures for the removal of broken glass from your school. Discussions should include types of glass that can be disposed of, how the glass is to be placed in the bin, whether glass is to be wrapped, contained in labelled boxes or left visible. Further, ensure information sharing of these procedures with Heads of Science, teachers, laboratory technicians, teacher aides and cleaning staff.

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[1] 'Laboratory safety', University of Sydney website, http://www.uws.edu.au/whs/whs/labsafety (Accessed April 2014)

[2] 'Laboratory safety', University of Sydney website, http://www.uws.edu.au/whs/whs/labsafety (Accessed April 2014)

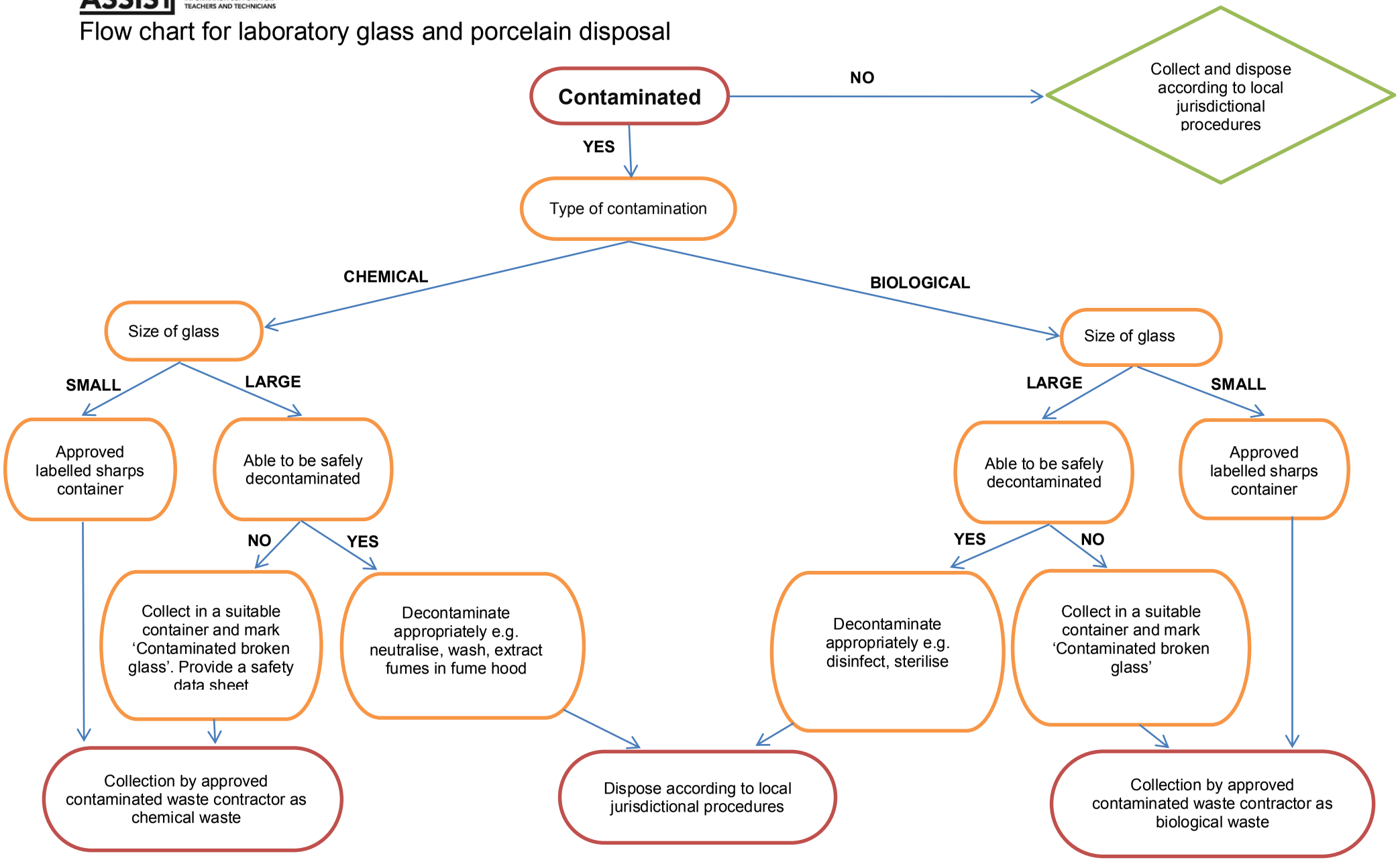
[3] "Glass', SITA Australia website, http://www.sita.com.au/community-education/site-tours-education/recycling-tips/glass/ (Accessed April 2014)

[4] 'HS321 Laboratory hazardous waste disposal guideline', UNSW website, https://www.ohs.unsw.edu.au/hs_procedures_forms/guidelines/HS321_Laboratory_Hazardous_Waste_Disposal_Guideline.pdf 09/04/2013 (Accessed April 2014)

[5] 'Laboratory safety', University of Sydney website, http://www.uws.edu.au/whs/whs/labsafety (Accessed April 2014)

ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

Flow chart for laboratory glass and porcelain disposal



ASSIST INFORMATION SHEET:

Labels for school science chemicals

In school science departments, many chemicals and solutions are sub packaged into small bottles and jars for use in the classroom situation. This requires having special labels to suit the size of the container that complies with legislation required for hazardous chemicals.

The model Work Health and Safety (WHS) laws have currently been adopted by every state and territory, except for Victoria and Western Australia. The Australian Capital Territory has not yet adopted the chemical regulations. The model WHS Regulations have referenced into them the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). This is an internationally agreed system developed by the United Nations.

There is a phase-in or transitional time for the implementation of this system, whereby the NOHSC labelling system can be used up until 31 December 2016. It is recommended that teachers and technicians who are responsible for labelling school science chemicals become familiar with the GHS requirements during the transition period and take advantage of any training sessions on offer. Science ASSIST will work towards improving the resources and support available to schools regarding labels for the implementation of the GHS.

Background information

Safe Work Australia is an independent Australian Government Statutory body that coordinates and develops national policy and strategies to improve work health and safety and workers' compensation in Australia. In order to achieve harmonisation (nationally consistent regulatory framework across all Australian jurisdictions) of the Work Health and Safety laws across Australia, Safe Work Australia has developed a model Act, model Regulations and model Codes of Practice.

These laws only become legally binding when they are formally enacted or passed by parliament in each jurisdiction. The Commonwealth and each state and territory is responsible for regulating and enforcing the laws in their jurisdiction. At the time of this information sheet, these model laws have been implemented in every jurisdiction except Victoria and Western Australia where pre-existing local health and safety laws continue to apply, and the WHS chemical regulations have not yet been adopted in the Australian Capital Territory. For jurisdictional progress on the model work health and safety laws see http://www.safeworkaustralia.gov.au/sites/swa/model-whs-laws/pages/jurisdictional-progress-whs-laws

The model WHS Regulations have referenced into them the 3rd Revised Edition of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). This is an internationally agreed system published by the United Nations and sometimes referred to as 'the purple book'.

We are currently in the middle of a transition period, where manufacturers and importers of chemicals are able to continue to use the NOHSC labelling system for workplace hazardous substances and dangerous goods up until 31 December 2016. This applies for chemicals which have been classified according to the Approved Criteria for Classifying Hazardous Substances and the ADG Code. For more detailed information regarding the Labelling of workplace hazardous

chemicals see http://www.safeworkaustralia.gov.au/sites/swa/whs-information/hazardous-chemicals/labelling/pages/labelling

Under the NOHSC system the terms 'Hazardous Substances' and 'Dangerous Goods' are used and under the GHS the term 'Hazardous Chemicals' is used.

For jurisdictions which have adopted the GHS-based system, up until the 31 December 2016 the following labelling documents apply for workplace chemicals. Either:

Hazardous Substances:
National Code of Practice for the Labelling of Workplace Substances [NOHSC: 2012 (1994)]
http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/cp1994labellingofsubstances
AND
Dangerous Goods:
Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG Code)
http://www.ntc.gov.au/viewpage.aspx?AreaId=35&DocumentId=1147
OR

Hazardous Chemicals:

Model Code of Practice - Labelling of Workplace Hazardous Chemicals
http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop

This code of practice should be used where the chemical has been classified according to the GHS, i.e. in conjunction with GHS-based safety data sheets.

After 31 December 2016 only the Model Code of Practice - Labelling of Workplace Hazardous Chemicals will apply for workplace chemicals in those jurisdictions which have adopted the model legislation.

The ADG Code will continue to apply to the transport of chemicals after the 31 December 2016. This means that the labelling on the outer packaging of the transport container will be compliant with the requirements of the ADG Code and the labelling on the inner package i.e. the chemical container will be compliant with either the NOHSC system or the GHS system (prior to 2017) and the GHS after 1 January 2017.

Note: In addition there are a range of other labelling requirements that may apply due to the complexity of the regulations that apply throughout Australia. For example, Agricultural and veterinary chemicals; Consumer and domestic chemicals (poisons); Therapeutic goods; and Dangerous goods during land transport.
http://www.safeworkaustralia.gov.au/sites/swa/whs-information/hazardous-chemicals/labelling/pages/labelling

Labelling information required for hazardous chemicals

This ASSIST Information Sheet is not a guide to producing labels suitable for the school science department, but a collation of relevant information as an interim measure until more detailed resources are developed.

It is recommended to download the reference document from the Safe Work Australia website in order to read the following excerpts in context which are taken from the 'Model Code of Practice - Labelling of Workplace Hazardous Chemicals'
http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop

Under the WHS Regulations, schools have a responsibility to ensure that any hazardous chemical that is used, handled or stored at the workplace is correctly labelled in accordance with Schedule 9 of the WHS Regulations. (Section 1.3)

When chemicals are purchased, they will have the manufacturer's label and should already contain the minimum requirements as detailed in Section 2.1 (see below). However in school science departments, many chemicals and solutions are sub packaged or decanted into small bottles and jars for use by students in the classroom situation. The definition of decant in the Code of Practice is "*to transfer a hazardous chemical from a correctly labelled container to another container within a workplace.*" (Section 3.3)

Schools need to ensure that these decanted containers are suitably labelled. Most schools have a subscription to a chemical management system that produces labels. However these are designed for use largely in industry, contain all the hazard and precautionary statements and when reduced in size for small containers, the font size is very difficult to read. Technicians who wish to produce labels which are completely satisfactory with respect to compliance, legibility and layout may need to use their own template for small containers.

There is provision in the Code of Practice for reduced labelling for decanted chemicals, however where the containers are used permanently for decanted chemicals they need to comply with the minimum requirements and the reduced labelling for small containers will apply (See below). The aim is to provide as much information on the hazards and safe use of the chemical on the label as possible.

Signal words, hazard and precautionary statements

The potential exists for duplication or redundancy of certain label elements where a hazardous chemical meets the criteria for more than one hazard class or category in the GHS. Duplicate or redundant information should not be included on a label. Rules of precedence of certain label elements and general guidance that should be used to determine when elements may be omitted from a label are provided in Appendix E. (See below). When deciding which information should be included in labels for small containers, schools need to make a judgement about which statements to include. Hazard and precautionary statement codes are for reference purposes only and should not be used on a label. (Section 2.4, see below)

Dimensions of text and pictograms

The text, hazard pictograms and other information on a label should be of a size and style that is easily legible and is appropriate to the size of the label and container. The minimum recommended text size, for a container less than 500mL, is 2.5mm (approximately size 8 font). (Section 4)

Pictograms vs Dangerous Goods diamonds

One aspect of the GHS, which has raised some concerns in schools is that the GHS has only one Flammables pictogram which replaces the six ADG diamonds corresponding to the six categories of flammable substances. Up to now, many schools have used the ADG codes to indicate the storage categories of flammable substances. The good news is that we can continue to use the ADG diamonds for the different categories of flammable substances; according to Chapter 2.4 of the Code of Practice, '*Class labels recommended for the transport of dangerous goods as specified in the ADG Code may be used instead of the relevant hazard pictograms specified in the GHS*.'

Science ASSIST will work towards improving the resources and support available to schools regarding labels for the implementation of the GHS. In the meantime the following excerpts from the Code of Practice are included below.

Excerpts from the Model Code of Practice - Labelling of Workplace Hazardous Chemicals http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop

'*2.1 What information must be included on a label?*

Regulation 335, Part 3 of Schedule 9

A hazardous chemical is correctly labelled if the chemical is packed in a container that includes the following:

- *is written in English*
- *the product identifier*
- *the name, Australian address and business telephone number of either the manufacturer or importer*
- *the identity and proportion disclosed, in accordance with Schedule 8 of the WHS Regulations, for each chemical ingredient*
- *any hazard pictogram(s) consistent with the correct classification(s) of the chemical*
- *any hazard statement(s), signal word and precautionary statement(s) that is consistent with the correct classification(s) of the chemical*
- *any information about the hazards, first aid and emergency procedures relevant to the chemical, which are not otherwise included in the hazard statement or precautionary statement, and*
- *the expiry date of the chemical, if applicable.'*

Safe Work Australia. 2011. *Labelling of Workplace Hazardous Chemicals – Code of Practice* http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop, p6.

'*2.4 Label elements*

The combination of label elements required on the label of a hazardous chemical is directly linked to its hazard classification. Label elements apply to classification endpoints or hazard categories and must be determined as specified in the GHS.

Appendix D includes tables listing all the elements that apply to each hazard class and category or division.

The potential exists for duplication or redundancy of certain label elements where a hazardous chemical meets the criteria for more than one hazard class or category in the GHS. Duplicate or redundant information should not be included on a label. Rules of precedence of certain label elements and general guidance that should be used to determine when elements may be omitted from a label are provided in Appendix E.

The signal word, hazard pictograms and hazard statements should be grouped together in a prominent position on the label, and located either immediately following or adjacent to the product identifier and chemical ingredients.

Signal words

Signal words are used to indicate the relative level of severity of a hazard. The GHS uses 'Danger' and 'Warning' as signal words. 'Danger' is used for a more severe or significant hazard, while 'Warning' is used for the less severe hazards.

Only one signal word should be present on any one label. If the signal word 'Danger' applies, then the signal word 'Warning' should not appear on the label.

Signal words should be represented in bold and uppercase text.

Hazard statements

Hazard statements describe the nature of a hazard, including the degree of hazard, where appropriate. A unique hazard statement is assigned to each hazard class and category. The hazard statements and corresponding hazard class and category are provided in Appendix D. All relevant hazard statements must appear on the label. Where a hazard classification results in hazard statements with duplicate information, the information should only appear once, in line with the rules of precedence outlined in Appendix E.

Additionally Appendix D lists 12 non-GHS hazard statements that should be included on the label, where relevant.

A unique hazard statement code is assigned to each hazard statement. The hazard statement code is intended to be used for reference purposes only. It is not part of the hazard statement and should not be used to replace it or be included on the label.

Hazard statements should be represented in bold and sentence case text.

Precautionary statements

Precautionary statements describe the recommended measures that should be taken to minimise or prevent adverse effects resulting from exposure to, or improper storage or handling of, a hazardous chemical. Precautionary statements are assigned to each hazard class and category.

Precautionary statements are separated into five categories:

- *Prevention statements refer to precautions to be taken to prevent an accident or exposure.*
- *Response statements refer to instructions in case of an accident.*
- *Storage statements refer to instructions for safe storage of the chemical.*
- *Disposal statements refer to appropriate disposal instructions.*
- *General statements for use as appropriate.*

The precautionary statements that correspond to each hazard class and category are provided in Appendix D. Not all precautionary statements relating to a particular hazard classification need to be used on the label. As a guide, a maximum of between six and ten precautionary statements should appear on the label, depending on the nature and severity of the hazards.

Where a hazard classification results in duplicate precautionary statements, the information should only appear once in line with the rules of precedence outlined in Appendix E.

A combination of precautionary statements may be used to save label space, improve readability and to provide flexibility in the application of precautionary phrases.

Related precautionary statements should be grouped together on a label to allow for ease of location. Precautionary statements should be printed in sentence case text.

A unique precautionary statement code is assigned to each precautionary statement. The precautionary statement code is intended to be used for reference purposes only. It is not part of the precautionary statement and should not be used to replace it or be included on the label.

The general precautionary statements refer to general precautionary measures to be taken, for example:

- *If medical advice is needed, have product container or label at hand.*
- *Keep out of reach of children.*
- *Read label before use.*

Unlike other precautionary statements, general precautionary statements are not linked to particular hazard classes or categories and their inclusion on labels of workplace hazardous chemicals is not mandatory.

Where general precautionary statements are used, they should be located in a prominent position on the label, for example adjacent to the product identifier. General precautionary statements should be printed in sentence case text.

Hazard pictograms

The GHS specifies nine hazard pictograms, having regard to physical, health and environmental hazards. These are provided in Appendix F of this Code.

Hazard pictograms must be included on the label in most cases. In some circumstances however, pictograms may be omitted from the label in line with the rules of precedence outlined in Appendix E. In all other cases, where pictograms are required, all the relevant hazard pictograms must be included on the label.

Hazard pictograms should be in the shape of a square set at an angle of 45^{o} (i.e. diamond-shaped) on its point. The hazard pictograms should have a black symbol on a white background with a red border or frame of sufficient width to be clearly visible. Pictograms with a black border may also be used.

Class labels recommended for the transport of dangerous goods as specified in the ADG Code may be used instead of the relevant hazard pictograms specified in the GHS. Never use both in the same label. A comparison of the hazard pictograms as specified in the GHS and the ADG Code class labels are shown in Appendix G[1].'

Safe Work Australia. 2011. *Labelling of Workplace Hazardous Chemicals – Code of Practice* http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop, p9–11.

[1] GHS pictograms can be downloaded from the GHS website at www.unece.org/trans/danger/publi/ghs/pictograms.html or *via* the GHS homepage at www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html.
Transport of Dangerous Goods class labels can be downloaded from the National Transport Commission website at http://www.ntc.gov.au/viewpage.aspx?documentid=1313

'*3.1 Small containers*

Regulation 335, Part 3 of Schedule 9

Where a hazardous chemical is packaged in a container that is too small to attach a label with information that is required of hazardous chemical labels in general, then the label must be written in English and include the following:

- *the product identifier*
- *the name, Australian address and business telephone number of either the manufacturer or importer.*
- *a hazard pictogram or hazard statement that is consistent with the correct classification of the chemical, and*
- *any other information required for hazardous chemicals labels in general that is reasonably practicable to include.*'

Safe Work Australia. 2011. *Labelling of Workplace Hazardous Chemicals – Code of Practice* http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop, p12.

'*3.3 Decanted or transferred hazardous chemicals*

Regulation 335, Part 3 of Schedule 9

If a hazardous chemical has been decanted or transferred from the container in which it was packed and it will not be used immediately or it is supplied to someone else, the label must, at a minimum, be written in English and include the following:

- *the product identifier, and*
- *a hazard pictogram or hazard statement consistent with the correct classification of the chemical.*

For the purposes of this Code, decant means to transfer a hazardous chemical from a correctly labelled container to another container within a workplace. Such a container may range from a small flask in a research laboratory to a large vessel that is used to contain reaction components prior to use in a mixing or reaction process.

Where a container is repeatedly used for decanting as part of normal work procedures or processes, a permanent label with all the general labelling information must be attached to the container. Permanently labelled containers must not be used to contain any other substances or mixtures than those specified on the label.'

Safe Work Australia. 2011. *Labelling of Workplace Hazardous Chemicals – Code of Practice* http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop, p14–15.

‘*APPENDIX E – PRECEDENCE RULES OF LABEL ELEMENTS*

Signal words

Where the signal word ‘Danger’ applies, the signal word ‘Warning’ should not appear concomitantly.

Hazard statements

Where hazard statements are required to be present on a label, then all of the assigned hazard statements must appear on the label except where:

- *the statement duplicates or conflicts with another statement or other hazard information that is required on the label*
- *omission of the statement would not decrease the level of protection or information in relation to the hazards.*

Precautionary statements

Where precautionary statements are required to be present on a label, then normally not more than six to ten precautionary statements are required, unless necessary to reflect the nature and the severity of the hazards. For example, precautionary statements can be omitted if:

- *the statement duplicates or conflicts with another statement or other hazard information that is required on the label; and*
- *omission of the statement would not decrease the level of protection or information in relation to the hazards.*

Any conflict that arises between precautionary statements that are present on labels may be resolved by modifying the statements. However, the new statement(s) must give equivalent levels of information or protection.’

Safe Work Australia. 2011. *Labelling of Workplace Hazardous Chemicals – Code of Practice* http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop, p81–82.

References

Safe Work Australia. 2011. *Labelling of Workplace Hazardous Chemicals – Code of Practice* http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-hazardous-chemicals-cop

United Nations Economic Commission for Europe (UNECE). 2009. *Globally Harmonized System of Classification and Labelling of Chemicals (GHS).* http://www.unece.org/trans/danger/publi/ghs/ghs_rev03/03files_e.html

ASSIST INFORMATION SHEET:

Latex allergies in schools

The last few decades have seen an increase in allergies to latex[1]. These allergic reactions develop in some people due to exposure to certain latex proteins and chemicals used in the manufacture of latex products.

In a school setting, items containing latex can be found across many departments and whilst frequent exposure is unlikely, latex allergies can be an issue for susceptible individuals. It is recommended that schools avoid or minimise the use of latex containing products to prevent the development of latex allergies in both staff and students.

Items containing latex in schools

The intent of this information sheet is to raise awareness of latex allergies and to encourage a sensible and a risk management approach to the use of latex products in schools. It is important to know which staff and students may be at risk, to know where latex products are used in schools and to have strategies in place to avoid or limit exposure especially when a person has been identified as having a latex allergy.

What is latex?

Latex is obtained from the sap of the rubber tree *Hevea brasiliensis*[1]. Latex is put through a manufacturing process with various chemicals to produce commonly used rubber products such as disposable latex gloves and balloons. Latex is also referred to as natural rubber latex.

What is a latex allergy?

A latex allergy is a reaction to latex proteins and chemicals used in the manufacture of latex products and when contact is made with the skin or mucous membranes[2]. During the manufacture of latex products such as balloons and gloves a dry powder, usually cornstarch, is added to prevent the rubber surfaces from sticking together. The allergy-causing proteins can stick to the cornstarch powder and can cause reactions in sensitive individuals when blowing up a balloon or breathing in the powder from the inside of latex gloves. The risk of developing allergic symptoms is also increased by frequent exposure to the latex proteins[1].

Who is at risk of developing a latex allergy?

- People who already experience allergies such as hay fever, asthma and eczema.
- People with certain food allergies in particular to banana, avocado, kiwi fruit and strawberries.
- People frequently exposed to latex products.
- People who have undergone multiple operations, such as those with spina bifida.

Signs and symptoms of a reaction to latex

Latex allergies can present in the form of skin irritation including redness, rash, hives and itching; itchy or watery eyes, asthma, swelling of the lips and face; respiratory symptoms, chest tightness and rarely, anaphylactic shock[2].

Risk management and prevention strategies

1. **Provide education and training to all school staff** to raise awareness about exposure to latex, how to recognise the symptoms of latex allergies and how to prevent and deal with allergic reactions. Include what to do in the case of an emergency.
2. **Identify staff and students** with a history of latex allergy or those who are at increased risk of developing a latex allergy and have health care plans for those at significant risk.
3. **Identify all products that contain latex and their location in the school.** This may include, but is not limited to:

    - **Classrooms/science laboratories**: disposable latex gloves, balloons, safety goggles, rubber bands, erasers, pipette filler bulbs.
    - **Sporting areas**: handles on racquets, rubber gym mats, balls, swimming caps/goggles.
    - **Cleaning/canteen/technology/home economics kitchens**: rubber gloves
    - **First aid (Sick bay, First Aid kits)**: hot water bottles, disposable latex gloves, some Band-aids/bandages and adhesive tapes.

4. Limit exposure to latex products and use non-latex alternatives where practicable. For example, in the science area:

    - Substitute latex gloves with non-latex gloves such as vinyl or nitrile.
    - If choosing to use latex gloves select powder free products.
    - Minimise the use of latex balloons or consider the use of non-latex balloons such as Mylar® or foil balloons.
    - Purchase synthetic rubber instead of natural rubber items.
    - If a latex-free product is not available then an alternate activity may need to be considered.
    - Follow good hand hygiene practices. Wash hands after removing gloves/handling latex products.

References and further reading:

[1] Australasian Society of Clinical Immunology and Allergy (ASCIA). 2015. *Latex allergy*. https://www.allergy.org.au/images/pcc/ASCIA_PCC_Latex_allergy_2015.pdf

[2] Sydney Children's Hospital. 2014. *Latex allergy.* Factsheet. https://www.schn.health.nsw.gov.au/files/factsheets/allergy_-_latex_allergy-en.pdf

Australasian Society of Clinical Immunology and Allergy (ASCIA). 2015. *Examples of risk minimisation strategies for schools, preschools and childcare services.* https://www.allergy.org.au/images/scc/ASCIA_Risk_minimisation_strategies_table_030315.pdf

'Creating a Safe School for Latex-Sensitive Children', American Latex Allergy Association website, http://latexallergyresources.org/articles/web-article-creating-safe-school-latex-sensitive-children (Accessed August 2017)

'Latex Allergy', Centers for Disease Control and Prevention (CDC) website, https://www.cdc.gov/healthcommunication/toolstemplates/entertainmented/tips/latexallergy.html (14 February 2011)

Workplace Health and Safety Queensland. 2013. *Latex allergy*. Version 2, February 2013. https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0020/83009/latex-allergy.pdf

ASSIST INFORMATION SHEET:

Risk management and risk assessment

'A safe and healthy workplace does not happen by chance or guesswork. It is everyone's responsibility to think about what could go wrong at the workplace and what the consequences could be. Then reasonably considered actions must be taken (in other words, whatever is 'reasonably practicable') to eliminate or minimise health and safety risks arising from any undertaking'. [1]

This process is known as 'risk management' and risk assessment is an important part of that process.

Risk management

It is a legal requirement under the Work Health and Safety legislation for every workplace to manage risks to health and safety so far as is reasonably practicable. Each workplace should implement a Risk Management policy to deal with these issues.

The aim of Risk Management is to minimise risks to ensure that no one is harmed and that there is no damage to property. It is a continuous process of identifying hazards, assessing risks and implementing the necessary control measures to reduce the level of risk. It involves effective communication and management of staff at all levels.

School science areas

Each school needs to establish its own risk management system that addresses reducing risks for workers as well as addressing the duty of care for students. Legislation does not specify the format that risk assessments should take and many discussions have been held regarding the requirements for risk assessments for activities conducted in science. School science areas deal with a diverse range of hazards such as physical, electrical, chemical, biological and other specialised hazards. Many activities are only conducted once a year possibly by different teachers and usually with different students, which increases the need for a risk assessment, as circumstances will be different. It is essential that the emphasis is on the thinking process involved in identifying the hazards, assessing the risks and then applying control measures to minimise the risks. The Science ASSIST Risk Assessment template is designed to help you in this process.

Science ASSIST recommends that a risk assessment is conducted and documented for all activities that involve a level of risk. This should take into consideration the site-specific details such as staff training, student behaviour, the activity conducted and school facilities.

The AS/NZS 2243.1 2005 *Safety in laboratories Part 1: 'Planning and operational aspects'* states:

> ***Section 3: Laboratory Safety and Emergency Management***
> ***3.1 LABORATORY SAFETY MANAGEMENT SYSTEMS***
> ***3.1.1 General***
> *'To manage occupational health and safety in a laboratory, laboratory safety systems shall be implemented. A laboratory safety system shall address the assessment and management of all risks and the provision of training, including hazard identification, for personnel. This system shall also address access to, and operations in, the laboratory pertaining to students, maintenance staff,*

contractors, visitors (including children), cleaners, security staff and animals (experimental and companion).'[2a]

Risk Assessment

A risk assessment is a systematic and recorded examination of the workplace and the activities conducted in it. A risk assessment is carried out to identify hazards, determine the likelihood of harm or damage occurring to people or property from these hazards and to determine control measures to eliminate or minimise the hazards.

The AS/NZS 2243.1 2005 *Safety in laboratories Part 1: 'Planning and operational aspects'* states:

> ***Section 3: Laboratory Safety and Emergency Management***
> ***3.1.2 Risk assessment***
> *'Risk assessments of all operations in the laboratory shall be carried out. Risk assessment can be described as a systematic use of the available information to identify hazards and to estimate the risks to staff, property or the environment and to take appropriate steps to avoid or mitigate identified consequences of those risks. For further information on risk identification, control and management see AS/NZS 4801.'*[2b]

A risk assessment generally involves a 4-step process:

1. **Identify the hazards**
2. **Assess the level of risk associated with the hazard**
3. **Implement control measures to address the risks**
4. **Monitor, review and document the effectiveness of the control measures**

1. IDENTIFY THE HAZARDS

Look for, identify and list all hazards associated with the activity/experiment/workplace.
A hazard is 'something that has the potential to cause harm to people, property or the environment.'[3] For example, laboratory glassware may not be normally considered hazardous, however if it is cracked, chipped or is broken it can have the potential to cause harm.

2. ASSESS THE LEVEL OF RISK ASSOCIATED WITH THE HAZARD

Assess the likelihood and potential consequences that the hazard(s) identified may cause harm to occur. "A 'risk' is the chance or probability of that hazard causing harm or damage to people, property or the environment."[3] For example, what are the chances of laboratory glassware being dropped and broken and what type of injury or damage could occur? A risk rating is a combination of the likelihood of something causing harm, and the severity of the harm it can cause. The level of risk increases as either the likelihood of harm or the severity of the harm increases.

A matrix such as this can be used to help rate risk levels:

	Consequences				
Likelihood	**Minor**	**First Aid**	**Major**	**Critical**	**Catastrophic**
Almost Certain	*Medium*	*High*	*High*	*Very High*	*Very High*
Likely	*Medium*	*Medium*	*High*	*High*	*Very High*
Possible	*Low*	*Medium*	*High*	*High*	*High*
Unlikely	*Low*	*Low*	*Medium*	*Medium*	*High*
Rare	*Low*	*Low*	*Medium*	*Medium*	*High*

This process is often named **CLR** – **C**onsequences – **L**ikelihood – **R**isk Rating.

3. IMPLEMENT CONTROL MEASURES TO ADDRESS THE RISKS

What action is required to reduce or eliminate the risk?

"A control is a mechanism or process that minimises the risk of the hazard becoming actual so protects people, property or the environment from the identified hazard."[3] A risk rating of high or very high would be considered significant and the activity should not be carried out without implementing effective control measures to reduce the risk to an acceptable level. The "hierarchy of risk controls" is often used in this process. It is a hierarchy because the steps are increasingly effective towards the top of the list. When it is not reasonably practicable to eliminate a hazard, then it is controlled by working through another or a number of control measures. For example, a science teacher may use plastic ware instead of glassware (substitution), give safety warnings (administrative), and require the use of eye protection for the activity (PPE).

This summarises the hierarchy of risk controls:

a. **ELIMINATION: Remove the hazard completely.** The risk is eliminated because the activity is not done. For example, a science teacher may decide not to use a particular chemical because it is too hazardous. This is the most effective control, but it is not always practicable.
b. **SUBSTITUTION: Is there a safer alternative?** Substituting a safer alternative reduces the risk. For example, a science teacher may decide to substitute with a less hazardous chemical. This is the second most effective control.
c. **ENGINEERING CONTROL: Change the work process, equipment or workplace to reduce the risk.** The risk is controlled through the use of a physical mechanism. Examples include the use of a fume cupboard to extract hazardous vapours or reducing the risk through creating a barrier or a distance between it and those present. This control depends on the effectiveness of the equipment or barrier used.
d. **ADMINISTRATIVE CONTROL: Implement guidelines/policies, use of signage, provide standard operating procedures, and offer training schemes to reduce the risk.** For example, a science teacher may warn students that a chemical is corrosive, and that they should avoid its contact with skin and eyes. Or the laboratory may have a sign to say that gloves must be worn when handling a particular material. This control works only if the advice is followed.
e. **PERSONAL PROTECTIVE EQUIPMENT (PPE): Provide personal protective equipment to reduce the risk.** The hazard is controlled through the wearing of items such as laboratory coats, safety glasses, facemasks or gloves. This control works only if the equipment is effective and is worn correctly.

4. MONITOR, REVIEW AND DOCUMENT THE EFFECTIVENESS OF THE CONTROL MEASURES:

It is important to conclude whether risks are adequately controlled before proceeding with the activity. If the control measures are not fully effective, then the 4-step risk assessment process begins again. If there are significant or uncertain risks that cannot be adequately controlled then the activity should not be carried out.

Risk control measures are subject to periodic monitoring and review to check their effectiveness and to ensure that no new hazards are created. All control measures should be supported with documented procedures, training, instruction and supervision in line with the WHS Act and Regulations. Consideration should be given to frequent consultation with staff, routine inspections and testing of equipment and the provision of training to maintain currency in policy and procedures.

Directions for completing the Science ASSIST Risk Assessment template**

1. **Record activity details**
   Record relevant details of the activity. When noting the year group consider the class size, ability level, any behavioural/special needs issues e.g. medical conditions of the students.
2. **List all equipment and substances in column 1**
   Carefully read through the activity protocol and identify and list:
   a. All physics and general equipment used in the activity including basic laboratory items
   b. All chemicals used and produced in the activity.
   c. All biological and geological materials used in the activity.
3. **Identify the type of hazard in column 2**
   Identify the hazards that are associated with the listed equipment and substances. Consider how the equipment or substance is used. More than one box may be crossed if multiple hazards are identified. Current SDS should be consulted for each of the chemicals used and produced along with equipment manuals and policies and procedures pertinent to individual schools. Use the 'Other' box to add details of additional hazards identified that are not listed.
4. **Assess the risks and identify controls and other measures in column 3**
   Assess the risk of any harm that may occur to people, property or the environment from the hazards identified using a risk matrix. Identify any control measures that may eliminate or minimize the risks. The choice of control should be guided by the hierarchy of risk control principles: If it is not practicable to eliminate a risk, then it is controlled by working through the other alternatives. More than one control measure may be required.
5. **Use the 'Other' box to add details of additional controls identified that are not listed.**
6. **Identify waste produced**
   List all the waste produced in the activity. Determine the appropriate disposal procedure for the waste produced by following local and state government guidelines and individual school policies and procedures. Consult Section 13 of each chemical SDS for how to correctly dispose of the chemical. More than one disposal procedure may be required. Use the 'Other' box to add details of additional disposal procedures identified that are not listed.
7. **Confirm Standard Operating Procedures**
   Confirm that the appropriate documentation has been read and understood for the activity. This may include some or all of the following: Standard Operating Procedures, Safety Data Sheets, equipment manuals, school policies and local and state guidelines. Indicate any further relevant information in the 'other comments' section.
8. **Conclusion**
   - If the assessment concludes that there are no significant risks or there are some risks but they can be adequately controlled, then the activity may be carried out after it has been signed off by the person carrying it out and authorised by a supervisor or head of department.
   - If the assessment concludes that there are significant or uncertain risks that cannot be adequately controlled then the activity should not be carried out. Further assessment of the risks and change of protocol or an alternative activity should be sought.
9. **Review**
   Risk assessments should be reviewed regularly to check their effectiveness and to ensure that no new hazards are introduced.

** The Risk Assessment assumes that the activity will be conducted in a science teaching area with the following facilities: electricity, running water, emergency shut-offs for electricity, gas if applicable, and water, regular testing and tagging of portable appliances; emergency contingencies such as evacuation/emergency plans, appropriate fire extinguishers, spill kits, hand washing facilities, eyewash/safety shower and first aid supplies. It is also assumed that all the necessary licensing requirements and approvals are obtained prior to the activity.

Related links

- Science ASSIST Risk Assessment template, Science ASSIST website http://assist.asta.edu.au/resource/2298/risk-assessment-template

- Links to jurisdictional risk management information:

  ACT: ACT Department of Education and Community Services 'Guidelines for risk management in ACT government senior school programs', 2001. Section 2 https://index.det.act.gov.au/resources/pdf/ipm_Science_Guide.pdf (password protected)

  NSW: NSW Department of Education and Communities 'Chemical Safety in Schools (CSIS)' resource package. NSW DEC website http://www.dec.nsw.gov.au/ Volume 1, Section 1.5 DEC Intranet, login required.

  NT: Northern Territory Government 'The Risk Management Process' NT Department of Education website http://www.education.nt.gov.au/__data/assets/pdf_file/0011/4106/risk_management_process.pdf (Accessed August 2015)

  QLD: Organisational Health, Queensland Department of Education Training and Employment 'Health and Safety Risk Assessment template' Qld DETE website http://education.qld.gov.au/health/docs/healthsafety/health-safety-risk-assessment-template.doc (August 2012)

  Organisational Health, Queensland Department of Education Training and Employment 'Making Health and Safety Risks V.1' Qld DETE website http://education.qld.gov.au/health/docs/healthsafety/managing-health-safety-fact-sheet.pdf (August 2012)

  SA: Health and safety services, SA Department of Education and Children's Services 'Risk Assessment Matrix' www.decd.sa.gov.au/docs/documents/1/riskassessmentmatrix.doc (July 2006

  Vic: Victorian Department of Education and Early Childhood Development 'Risk analysis tools' http://www.education.vic.gov.au/documents/school/principals/safety/sgformriskanalysistools.doc

  WA: 'Policies Risk and Business Continuity Management' WA Department of Education and Training http://www.det.wa.edu.au/policies/detcms/policy-planning-and-accountability/policies-framework/policies/risk-and-business-continuity-management.en?oid=au.edu.wa.det.cms.contenttypes.Policy-id-9351425 (June 2015)

- Links to the health and safety legislation that covers your school see:
  'AIS:Links – Workplace Health and Safety (WHS)' Science ASSIST website http://assist.asta.edu.au/resource/650/ais-links-%E2%80%94-workplace-health-and-safety-whs (May 2014)

- Links to other support materials see:
  'AIS: Links — Risk assessment and hazard management', Science ASSIST website
  http://assist.asta.edu.au/resource/651/ais-links-%E2%80%94-risk-assessment-and-hazard-management (October 2014)

References

[1] Safe Work Australia 'How to manage work health and safety risks – Code of Practice', Safe Work Australia website
http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/633/How_to_Manage_Work_Health_and_Safety_Risks.pdf (December 2011)

[2a,b] AS/NZS 2243.1 2005 *Safety in laboratories Part 1: Planning and operational aspects.* These extracts from AS/NZS 2243.1 2005 Safety in laboratories Part 1: 'Planning and operational aspects' reproduced with permission from SAI Global Ltd under Licence 1407-c117

[3] Northern Territory Government. 'Risk Management Process' NT Department of Education website
http://www.education.nt.gov.au/__data/assets/pdf_file/0011/4106/risk_management_process.pdf
(Accessed August 2015)

AS/NZS ISO 31000:2009 Risk Management – Principles and guidelines
http://infostore.saiglobal.com/store/Details.aspx?ProductID=1378670

Australian Government ComLaw 'Work Health and Safety Act 2011' ComLaw website
http://www.comlaw.gov.au/Details/C2013C00253 (May 2014)

Australian Government ComLaw 'Work Health and Safety Regulations 2011' ComLaw website
http://www.comlaw.gov.au/Details/F2012C00904 (December 2012)

'Do a Risk Assessment' Office of Regulatory Services, Worksafe ACT website
http://www.worksafety.act.gov.au/page/view/1039 (September 2014)

ASSIST INFORMATION SHEET:

School science area security

Security of the school science department is an important subject that is often overlooked in the management of the school as a whole. There are many items contained in a science department which are expensive to replace or, of more concern, can be used in the manufacture of illegal drugs or explosives. This information sheet is mainly concerned with the dangers rather than the costs.

School science areas contain hazardous areas, substances and specialised equipment that require special attention regarding security. Some aspects that require particular consideration include:

- Laboratories, preparation and storerooms
- Certain chemicals
- Chemical balances
- Radioactive sources
- Lasers
- Glassware such as round bottom flasks and distillation equipment

It is difficult to cover all possible situations in one document. The aim of this information sheet is to provide some starting points to be considered and then adapted to individual situations.

Policy

Each school should develop its own policy in regards to security. Points to be considered include:

- **Control of access**
  - Lock rooms (doors and windows) whenever an authorised person is not present.
  - Ensure good management of keys to authorised personnel for laboratories, storerooms and preparation areas, including the return of keys from people who leave the workplace.
  - Cover street side windows with blinds to reduce visibility of laboratory equipment and chemicals. It is best to have chemical storerooms with no windows.
  - Limit access to all chemical storage areas.
  - Monitor access by visitors such as tradespeople and service providers, by systems such as escorting them on site; signing in and out procedures; and/or the wearing of visitor badges.
  - Restrict after-hours access.
- **Stocktakes and inventories**
  - Conduct regular stocktakes and maintain inventories to fully account for all chemicals and equipment including their location.
  - Develop a reporting system for loss and theft.
  - Ensure that desirable items, e.g. balances and distillation equipment are kept in secure locations.

- **Lab procedures/training**
    - Ensure all staff are aware of all security procedures.
    - Only purchase and therefore only store minimum quantities of chemicals. (It is preferable to order chemicals more regularly, rather than hoarding big quantities.)
    - Ensure deliveries of equipment/chemicals to schools are not left unattended, especially during busy periods.
    - Only use minimum quantities of chemicals and equipment in science practical classes and establish and maintain a system of counting certain items in and out e.g. scalpels.
    - Secure certain equipment to benches with cables/pad-locks e.g. computers.

Laboratories, preparation rooms and storerooms

Laboratories have particular hazards that are not present in ordinary classrooms. These include laboratory glassware, equipment, tools, fire extinguishers and specialist fittings, for example, gas taps. Laboratory benches and equipment may also have residues of chemical or biological materials that present unique hazards. Unsupervised access to students could result in personal injury to students or damage to property through either accidental breakage or deliberate vandalism.

Preparation rooms and storerooms may contain a range of equipment, resources and chemicals that can be expensive, difficult to replace, hazardous and/or desirable for illegal purposes such as in the manufacture of drugs or explosives. There may also be a wide variety of equipment in the process of being collated for practical activities.

Science ASSIST strongly recommends that all science rooms are locked unless a teacher or other authorised person is present.

Chemicals

All school science departments possess chemicals that have the potential for harm or injury if mis-used or mishandled. It is therefore imperative that measures are taken to ensure the security of the chemical storage areas, that they are well maintained and access to them is controlled and restricted to authorised members of staff. Students should not have access.

Each school or school governing body should therefore decide who has access to the keys to the chemical storage area(s). The lesser number of keys available means there is a lesser chance of unauthorised people gaining access. It is also important that anybody who does have access is well trained in handling the chemicals stored within. Consideration of security measures for the chemical storage area(s) at schools should include:

1. Keys to the chemical storeroom should be on a whole school master system for emergency access, and also on a **separate key to general classroom or science rooms**
2. Other chemical storage areas, such as storage cabinets located outside the main chemical storeroom e.g. in a preparation room, should be locked and access to keys restricted.
3. Limit access to authorised staff such as
    - Staff member responsible for issuing keys
    - Head of the Science Department
    - Senior chemistry teacher
    - Science technicians

Of particular concern are chemicals that have been identified as precursor chemicals to the manufacture of drugs or explosives, other chemicals of security concern, poisons and those classified as Dangerous Goods. For some of these chemicals, a permit or end user declaration (EUD) may be required before purchasing.

AS/NZS 2243.2:2006 *Safety in laboratories Part 2: Chemical aspects* states:

> *"**3.2.3 Security***
>
> *Chemicals such as controlled substances, drugs, poisons and radioactive substances shall be used and stored so that they do not present a risk to persons in the vicinity and are secure against theft or unauthorised tampering.*
>
> *Note: In Australia, this would also include high consequence dangerous good"*[1]

Chemicals of a national security concern: Information on ninety-six chemicals considered a potential security concern desirable for the manufacture of explosives or chemical weapons can be found at http://www.nationalsecurity.gov.au/ChemicalSecurity/Pages/default.aspx

Of these ninety-six, eighty-four are identified as toxic and either industrial or Agvet chemicals, eleven as precursor chemicals and one, security sensitive ammonium nitrate, is regulated independently. The National Code of Practice for Chemicals of Security Concern covers any quantity of the eleven precursors to explosives. This includes chemicals such as hydrogen peroxide, nitric acid and potassium nitrate, which would be found in most school chemical storerooms.

SSAN: Ammonium nitrate is a chemical of high security concern and a chemical that may be found in some school science laboratories. Where it occurs in solid form in concentrations above 45%, it is also referred to as security sensitive ammonium nitrate (SSAN). It does not appear in the above list of eleven chemicals of high security concern because its availability and use are highly regulated by individual state and territory legislation. In 2004, the Council of Australian Governments' (COAG) Meeting agreed upon a national approach to the management of SSAN with regulation at a state level. See http://archive.coag.gov.au/coag_meeting_outcomes/2004-06-25/index.cfm Some states permit pure SSAN in quantities less than 3kg in educational institutions where there is a curriculum requirement. An end user declaration (EUD) may be required before purchasing. However, **Science ASSIST recommends the use of substitutes** for its curriculum uses. For example, using sodium nitrate, sodium acetate, or sodium thiosulfate for a 'heat of solution' activity.

Drug precursors: Information regarding chemicals (and other items) stored at schools considered desirable for the illegal drug manufacturing area can be found in the Code of Practice for Supply Diversion into Illicit Drug Manufacture. The objectives of this code are to "*promote effective chemical security management practices throughout the chemical supply chain*"[2]. It includes a "Self-assessment" for the security of the chemicals. Measures include controlling physical access, limiting access to relevant staff and maintaining regular checks of stock levels.

Poisons: Some chemicals that are used in schools are classified as poisons and listed in the *Poisons Standard* in Schedules based on their level of toxicity and their use. Poisons that are commonly used in schools are classified as a Schedule 5 (Caution), Schedule 6 (Poison) and Schedule 7 (Dangerous poison). Further details of the classification of medicines and poisons into Schedules can be found in *The Poisons Standard* also known as *The Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP)*. The regulation of scheduled poisons is managed by the Health Department in each state and territory of Australia.

Dangerous goods: Even though these are not chemicals of national security concern as listed by the Government, they are still hazardous and dangerous in the hands of unskilled and unauthorised people and require adequate security measures. The guidance material regarding dangerous goods and hazardous chemicals concentrates on the safe handling of these chemicals. However, it also includes references to restricting access to authorised personnel, for example:

> "In view of the *hazards* associated with the storage and *handling* of *dangerous goods*, access to *premises* and work areas must be restricted to those having a legitimate purpose." (S30)[3]
>
> "You must, so far as is reasonably practicable, prevent access to the premises by unauthorised persons."(S21.12)[4]

Balances

Chemical balances are an obvious target for people involved in illegal activities. These are very portable devices and easily transported. It is highly recommended that they be stored in a locked cupboard within a restricted area such as the laboratory preparation area.

Radioactive sources

It is essential to safely and securely store radioactive sources. They should be stored in a locked lead lined metal container within a locked cupboard or drawer, with a unique key, in a room which should only be accessible by staff members. An inventory of all radioactive sources should be kept along with keeping a log, which should be filled in when a source is removed, by whom and when it is returned. The detail of requirements for the security of, and access to, the sources likely to be used in a school is covered in the SOP: Handling sealed radioactive sources. Further information can also be found in the ARPANSA document *Safety Guide for the Use of Radiation in Schools (2012)*

Lasers

Lasers are another very portable item which requires special attention. The type of lasers that are permitted to be used in schools are of a low power rating, however, if they are used inappropriately they may still be of a health concern. Secure storage of these should be in an area where access is limited. The details of requirements for the security of and access to lasers likely to be used in a school are covered in parts 1 and 2 of SOP: Use of lasers in schools. Further information can also be found in the ARPANSA document *Safety Guide for the Use of Radiation in Schools (2012)*

Glassware

Every school science area will have various items of glassware that may attract people involved in illegal activities. It is not generally practicable to keep all glassware securely stored away. Some items like round bottom flasks and distillation sets require more thought as they are sought after and mentioned in the Code of Practice for Supply Diversion into Illicit Drug Manufacture

References:

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ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEET

School science laboratory gas-fitting requirements

The installation and supply of gas to school science laboratories should be according to:

- *AS/NZS 1596:2014 The storage and handling of LP Gas*
- *AS/NZS 2982:2010 Laboratory design and construction*
- *AS/NZS 5601.1:2013 Gas installations Part 1: General installations*

These Australian/New Zealand standards set out the minimum requirements for installations and are subject to the local technical regulators for each state and territory, which may have additional requirements that exceed the requirements as stated in the Australian Standards. Some relevant aspects to be considered in school science laboratory settings are detailed below.

Isolation devices and signage

An isolation device is mandatory and can be either a manual or automatic shut-off valve that is readily accessible and well signed. A manual shut-off needs to be a single action lever of the quarter turn type, where the gas supply is open when the handle is in line with the pipe and closed when the handle is across the pipe.

Current requirements for secondary school science laboratories specify an appropriately located push-button shut-off, with key operated manual reset. It should ideally be located adjacent to the main electrical shut-off near the teacher's bench on an egress path.

Clear signage that is legible and durable is required. Suggested wording for the notice is:

'GAS ISOLATION: Turn off when gas is not in use or in the case of emergency. Before turning on, ensure all Bunsen burners are turned off'.

Attachment of Bunsen burners to the gas outlet

There are two styles of fittings permitted:

1. **Push-on connectors**
   The 'push-on connectors' are also referred to as 'fixed turret type outlets' or 'laboratory gas turret cocks'. These types of fitting, operate on low gas pressure and the Bunsen burner tubing slides over the special 'fir tree' fitting and is held on by friction. This style has many advantages over the bayonet style fitting. The tubing from the Bunsen burner connects easily straight onto the fitting. Once this is secure, the gas can easily be turned on using the lever in the fitting to enable easy lighting of the Bunsen burner. It is clear to see that the tap is on or off. The experience of many decades of their use in school science areas indicates that they are safe, and rarely if ever accidentally dislodged. However should this happen, the gas supply is quickly and easily cut off by the tap in the turret.

2. **Quick-connect devices (also referred to as bayonet fittings)**
   These devices are subject to some local requirements. For example, they are not permitted in schools in Victoria. They are not commonly used in Australian school science areas.

Whilst the bayonet style fittings might be permitted, it is recommended that a local risk assessment be conducted regarding the use of these fittings taking into consideration the following:

- There are difficulties involved with connecting the 'quick-connect devices'. It usually requires at least two operators to be involved in the procedure: one to push in the connector and the second person to light the Bunsen. It has also been reported in some schools that teachers and students require additional help to push in and twist the connection in place, sometimes requiring the use of pliers to assist.
- Where inline valves/taps are connected to the hosing between the bayonet fitting and the Bunsen burners, stability of the Bunsen burner can be affected causing it to tip over, creating a serious fire hazard.
- The bayonet style fitting has no tap or valve for each outlet, so in the event of an incident such as a burning leak from a split hose, the individual gas supply cannot be turned off.

Regarding the tubing required for Bunsen burners, the following points should be considered:

- The statements in the SDSs for both LPG and LNG give instructions not to use natural rubber flexible hoses.
- It is important to have a flexible tubing adequate for the function.
- PVC tends to be rigid and has a memory for coiling, which can create a hazard of the Bunsen burner falling over.
- Silicone tubing appears to be a very suitable alternative to rubber tubing for use with Bunsen burners. Although more expensive, it has a much longer life span and is more heat resistant. It is also not prone to splitting or becoming brittle.
- All tubing should be checked periodically for cracks, hardening and other damage.

Regarding reduced gas flow through the Bunsen burner, one or both of the following can cause this:

- Blockages in the jets – these may need to be cleaned due to possible blockages or replaced. This is the most common cause.
- A reduced gas pressure that is coming through the reticulated service – the gas pressure may need to be tested and the gas regulator adjusted or replaced.

Science ASSIST recommendations

Whilst both push-on connectors and bayonet type gas fittings are permitted, Science ASSIST recommends the use of push-on connectors in conjunction with silicone tubing.

References

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ASSIST INFORMATION SHEET:

3D printer safety in schools

3D printing is a relatively new technology and industry and is also one of the latest technologies to enter schools. Prior to the purchase of 3D printers for a school it is important to consider all facility, site and safety requirements of the hardware and the thermoplastic/s to be used so any risks can be minimised.

Operational and safety considerations

- **Siting:** Follow the manufacturer's instructions for proper siting, ensuring printer is installed on a level and stable and surface. If the surface is not level the objects printed maybe distorted. The area where printer/s are located should be well ventilated.
- **Protection from heat and moving parts:** Safety guards should enclose 3D printers to ensure there is no exposure to moving parts. Enclosures will also prevent students from touching the hot extruder whilst 3D printing is in process and whilst material, nozzle and platform are cooling once printing is complete.
- **Maintenance:** Ensure regular electrical testing and tagging and compliance with Australian Standards for manufacturing.
- **Scrapers, tools:** Sharpened scrapers are often used to remove the print off the printer bed and to also clean the printer bed. Use with care.[1]
- **Users:** 3D printers should only be used and operated by appropriately trained and authorised personnel.

Thermoplastics and emissions

Filaments

The two most common types of filament for 3D printing in schools are the thermoplastics Acrylonitrile butadiene styrene (ABS) and Polylactic acid (PLA).

ABS is an oil-based polymer. It is a strong, sturdy material that prints projects with structural integrity and resilience. In industry it is used for constructing things such as automotive trim, protective headgear and LEGO® building blocks. ABS filament has a high melting point and so has a tendency to warp and must be printed on a heated bed.

PLA is made from renewable, organic resources such as sugarcane and cornstarch. It is, therefore, biodegradable and used in disposable plastic cups and food packaging. In 3D printing PLA produces a superior level of print detail and finer aesthetic quality. Due to its low melting point it lays on the print bed with little shrinkage.

For school use, PLA is considered a safer option than ABS.[1,5]

For Safety Data Sheets for a range of both ABS and PLA filaments see the Sigma-Aldrich website https://www.sigmaaldrich.com/catalog/search?term=3D+printing+filament&interface=All&N=0&mode=match%20partialmax&lang=en&region=AU&focus=product

Emissions

There is little known about the types and magnitude of emissions from desktop 3D printers and there are currently no standards that measure or assess the emissions. As a result, there is not much known about the possible impact on the safety and health of users.

- **Risks and controls of emissions and ultrafine particles**

Under GHS Classification neither ABS nor PLA are considered a hazardous substance or mixture[2]. However, studies[3] have concluded that 3D printer filament, combined with intense heating releases emissions (fumes and ultrafine particles) that may pose health risks to users. Both filament types will give off fumes as they are heated and these may cause eye, skin and respiratory tract irritation. Overexposure may cause headaches and nausea.

Care also needs to be exercised when conducting post-processing activities, such as sanding or polishing, which may generate ultrafine particles.

To mitigate risk, 'all reasonable steps should be taken to limit the exposure of users to fumes and particles generated by 3D printers'.[4]

- **Ventilation and filters**

Ideally, each printer should have a high efficiency particulate air (HEPA) filter and a carbon filter. HEPA filters remove the ultrafine particles and carbon filters trap the fumes. The printers should also be situated in a well-ventilated area[5].

Task ventilation could be useful in a school setting. Conducting 3D printer work inside a fume cupboard or a low flow enclosure to prevent fume exposure is a viable option.

It is generally recommended substituting ABS filament for the safer PLA filament for use in 3D printers in the school environment. If, however, ABS or any other material that is not PLA is required, then an enclosure with an inbuilt filter is recommended.

Considering the issue of air-conditioning, it is best if it is there is an outside air intake or else there may be insufficient air changeover. One would have to take into consideration the size of the room, the air exchange, the type of filament being used and how long it was operating for.

Science ASSIST recommends the following to reduce the risks associated with 3D printer emissions:

- 3D printers should ONLY be situated in a **large, well-ventilated room** to minimise exposure to particle and gaseous emissions.
- If at all possible, purchase printers that are **enclosed and have inbuilt filters** so fumes and particulates are contained.
- Use **PLA filament** rather than ABS filament.

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ASSIST INFORMATION SHEET:

Microscope choices for schools

Microscopes used in school science laboratories have traditionally been of two basic types, compound or bright field (high power) and stereo or dissecting (low power). Technology has advanced over the last few decades to produce digital microscopes and affordable options for capturing images and videos.

When choosing a microscope consideration needs to be given to the application, skill level of staff and students and budget. Microscopes range in quality and price and are used for different purposes.

Compound microscopes

Compound microscopes use a system of visible transmitted light and lenses to magnify images of thin specimens on microscope slides. The light passes through the specimen on the slide and the image is viewed through the eyepieces.

Most education quality microscopes contain a 10x eyepiece and three objectives of 4x, 10x and 40x. Magnification is calculated by multiplying the power of the eyepiece by the objective, so this combination allows a magnification of 40x, 100x and 400x. For many high power applications in schools, such as observing onion cells, root, leaf, stem and blood cells, a total 400x magnification is sufficient. The addition of a 100x oil immersion objective will allow magnification up to 1000x. This high magnification is required for observing greater cell detail and for studying microorganisms such as bacteria. In order to achieve the 1000x magnification you need to apply immersion oil to the slide and make careful adjustments to the contrast and focus.

Compound microscopes come with a monocular or binocular head. Monocular microscopes are generally a cheaper option. Cordless versions are now available and they come with a rechargeable battery and charger.

Important characteristics to look for include:

- Good quality optics to produce increased resolution.
- Ease of use. Models with mirrors can be hard to use, it is best to purchase a model with a built in light source. Monocular versions are easier to use than binocular microscopes.
- LED light source with dimmer for a longer bulb life and for extended viewing of live specimens due to the cooler light source.
- Mechanical stage for more precise slide control.
- Adjustable iris diaphragm to provide better image contrast.
- Fine and course focussing.

Stereo or dissecting microscopes

Stereo or dissecting microscopes generally use a system of reflected light rather than transmitted light.

These microscopes have a lower magnification power than compound microscopes. These microscopes have two eyepieces and two objective lens using separate optical paths. This produces a stereo or 3-dimensional image of the specimen. Magnification is calculated by multiplying the power of the eyepiece, usually 10x, by the objective, often 2x and 4x, so this

combination allows a magnification of 20x and 40x. They are used to examine larger objects in 3D, such as rocks, crystals, insects, leaves, fungi and fossils, rather than cells. For younger students the lower magnification (10x) is best as it produces a larger field of view. For more close-up and detailed work, including carrying out dissections, the higher magnification (40x) is recommended. Modern models utilise LED lights and can be purchased corded or cordless.

Digital microscopes

A digital microscope differs from a traditional microscope by being equipped with a digital camera, which allows images to be transferred to and viewed via a computer monitor. The main advantages of this technology include:

- Removal of the need to observe images directly through an eyepiece.
- Still and live images can be viewed on a variety of monitors such as computer screens, projector screens and smartboards.
- Images can be viewed by groups of students in real time and in remote locations providing education opportunities for students that were once unavailable. All students can get to see the same image.
- Images can be obtained faster and easier than trying to set up, adjust and view through a traditional microscope. Good for inexperienced users.
- Images can be saved, printed and emailed. Software is available to zoom in and out, count cells and make measurements.
- The quality of the images is generally better with digital microscopes.

Magnification is determined differently between a traditional and a digital microscope. With a traditional microscope magnification is the product of the eyepiece and the objective lens. A digital microscope has eliminated the eyepiece so the size of the monitor of the computer is the influencing factor of magnification and has the capacity for greater magnification than a traditional microscope. The computer monitor has varying physical dimensions and pixel resolutions, plus software that can resize an area visualised on the screen.

There are several options when looking to purchase a digital microscope.

- **Portable USB digital microscopes:** These are hand held units that can be taken into the field and are attached to a laptop or tablet. They offer low magnification around 1x to 200x and are used to examine larger objects like the traditional stereo microscopes. Final image quality is around two megapixels.
- **Digital eyepiece camera:** A small digital camera that replaces the eyepiece of a traditional compound or stereo microscope. The digital eyepiece camera is attached to a computer via a USB port. Computer software is provided that allows you to take still and video images. Compound microscopes with a digital eyepiece camera are able to view at the cellular level just like the traditional microscopes. Stereo microscopes with a digital eye piece camera are able to view larger objects just like traditional stereo microscopes.
- **Fully integrated digital microscopes:** These are microscopes that include a fully built-in digital camera. These are a more expensive option.

New photomicrography options and microscope alternatives

Photomicrography using compact digital cameras

Images seen through the light microscope can be photographed through the eyepiece with a compact digital camera with an auto focus, optical zoom and LCD screen. The intensity of the microscope light source is set to maximum and the camera lens is held against the microscope eyepiece.

The camera can be held by hand or set up on a tripod for stability. Looking at the camera's LCD viewfinder the position and distance between the eyepiece and the camera lens is adjusted to centre and focus the image. A picture is taken when the image is in focus. Short video can also be taken of motile organisms such as found in a drop of pond water.

Photomicrography using a smartphone

Images seen through the light microscope can also be photographed through the eyepiece with the lens of a smartphone camera. The camera lens is held to the microscope eyepiece and the image is viewed through the phone's screen. By adjusting the distance between the phone and the microscope lens the image fills the screen. The camera can be focussed and the image captured quickly. The image produced can be manipulated using the camera functions and can be emailed, sent by text or uploaded. The use of a smartphone in this manner brings an exciting new tool for students and teachers. Video can also be taken. Image quality is dependent on proper alignment of the camera and eyepiece lens, resolution of the image with the microscope, resolution, focal length and settings of the smartphone camera. These factors are dependent on the model of the camera and microscope being used. The main limitation is image blurring. It is difficult to remain steady whilst holding the camera and taking the photo. Peripheral darkening of the image can also occur.

Inexpensive and easy to use adapters are available to attach mobile phones to the ocular lens of a light microscope, which helps to address some of these limitations. They assist in making it easier to align the camera with the microscope eyepiece lens and remove vibration and blurring issues. Some are adaptable to the different type and size of phones and allow movement of the phone along the x and y axis for better alignment with the eyepiece optics. Others are specific to the type of phone being used.

Adaptor to convert a smartphone into a microscope

Technology has now developed clip and stick on lens units, which can turn any smartphone's camera into a basic microscope. They use additional lenses that clip or stick onto a smartphone plus the integrated flash of the phone. Many claim that they are capable of viewing microscopic organisms and animal and plant cells[1]. This clip-on can also be made using a 3D printer and purchasing a camera lens.[1,2]

Handheld microscopes

There is a wide range of portable pocket sized handheld microscopes available that may be cheaper options for primary schools or for fieldwork. These have either traditional or digital lenses and use either natural light or inbuilt battery powered LED light sources.

BioViewers

BioViewers are instruments like microscopes and are used to magnify slides (photomicrographs) of cells covering areas such as animal biology, plants, microbiology and ecology to name but a few. They require no power source, batteries or light source. They use ambient light focussed onto a white screen. They can be used in the classroom and in the field and are robust, lightweight and maintenance free. Sets of slides are available as BioSets. BioSets are strips of around eight slides accompanied by text information explaining each slide. These are available from science suppliers. See our list of school science suppliers (https://assist.asta.edu.au/resource/664/school-science-suppliers).

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ASSIST INFORMATION SHEET:

Plant and equipment maintenance and servicing schedules for optimum performance, safety and to meet compliance

*"**Good housekeeping** is one of the **best aids to safety** with mechanical apparatus. This implies the need for tidiness, cleanliness, clear work areas, proper use and **timely maintenance of plant and equipment.**"* [1]

Schools should develop their own maintenance and servicing schedule for all emergency equipment, plant and mechanical fixtures, electrical and electronic devices etc. based on site specific risk assessments.

"All maintenance shall be conducted by competent persons in accordance with the equipment manufacturer's instructions and the procedures for the laboratory or organization"(6.1)[2]. Accreditation or compliance certificates must be obtained and displayed for certain equipment and fixtures. Written records of regular inspections and servicing should also be maintained.

Science ASSIST recommends the following guidelines for several main fixtures/equipment commonly found in school science areas, which require regular servicing and sometimes a form of compliance certification or tagging.

A few points to note:

- Manufacturers shall provide operation, inspection and maintenance instructions, which shall be readily accessible to the person providing the maintenance and inspection.
- Testing and/or maintenance shall be carried out by a **competent person**.
- A competent person is defined as "*A person who has acquired through training, qualifications or experience, or a combination of these, the knowledge and skills enabling that person to perform a specified task*."[3]
- It may be necessary for some maintenance and service schedules to be conducted by a licenced contractor such as a plumber or an independent National Association of Testing Authorities, Australia (NATA) accredited service provider.
- Records of inspection and testing together with findings should be kept. Keeping records helps demonstrate compliance activities with the risk management process.
- Non-compliant equipment should be reported to the school's administration to arrange for servicing to comply with requirements or for decommissioning and replacement.
- Inspections should occur at a minimum on an annual basis
- Science ASSIST has a few previously published related resources. Links are given later in this document.

The items listed below are in alphabetical order not in order of importance.

Item and relevant AS/NZ Standard and/or Code of Practice	Frequency of testing	Person carrying out testing/inspection	Certification/Tag/Records	Comments
1. Chemical store ventilation system: extractor fan or natural ventilation				
AS/NZS 2243.10:2014 *Safety in laboratories, Part 10: Storage of Chemicals* AS1940:2017 *The storage and handling of flammable and combustible liquids* *Model Code of Practice – Managing risks of hazardous chemicals in the workplace*	The model Code of Practice states: *Regular checks of these systems should be included in planned maintenance schedules to ensure that vents remain unobstructed.* (p.35) *To ensure the effectiveness of ventilation systems, they should be designed in accordance with appropriate technical standards, and installed and maintained by qualified or experienced persons, such as engineers or occupational hygienists.* (p.36) Science ASSIST recommends **regular** inspections and at a minimum inspected **annually**.	A competent person could make a general inspection such as checking and cleaning of air vents A qualified person such as an electrician should conduct inspection and servicing of exhaust fans. A qualified person such as an engineer or occupational hygienist should conduct inspection and/or servicing of full mechanical ventilation systems that meet all the Australian Standard requirements.	Records of inspections and servicing should be kept.	School science chemical storerooms vary considerably in the types and quantities of chemicals they store and also the facilities in which chemicals are stored. The ventilation needs to be based upon a site-specific assessment. If inadequate ventilation is provided then appropriate control measures need to be implemented to bring it up to the required standard. Mechanical ventilation system of the chemical storage room should conform to AS/NZS 2243.10:2014 and AS1940:2017. See also: • Chemical Storage • Chemical Store • GUIDELINES for the design and planning of secondary school science facilities in Australian schools

Item and relevant AS/NZ Standard and/or Code of Practice	Frequency of testing	Person carrying out testing/inspection	Certification/Tag/Records	Comments
2. Electrical equipment (Portable)				
AS/NZS 3760:2010 *In-service safety inspection and testing of electrical equipment* *Model Code of Practice – Managing electrical risks in the workplace*	The model Code of Practice states: *The nature and frequency of inspection and testing will vary depending on the nature of the workplace, its environment and the risks associated with the electrical equipment.* (p.21) *AS/NZS 3760:2010 sets out indicative inspection and testing intervals for certain electrical equipment, including RCDs, used in a variety of different operating environments.* (p.21) Science ASSIST recommends **regular visual inspection** along with **annual testing and tagging.**	The model Code of Practice states: *For the purposes of the testing… a competent person includes a person who is licenced or registered to perform electrical work under a law relating to electrical safety or occupational licensing."* (p.24)	A record of testing must specify the following: • The name of the person who carried out the testing. • The date of the testing • The outcome of the testing. • The date on which the next testing must be carried out. The record may be in the form of a tag attached to the electrical equipment tested.	Equipment that has failed the electrical safety test should be labelled as 'out of service' and removed from usage. It should be either: • repaired and retested or • removed from the workplace permanently (It is recommended to cut off the cord where unsafe equipment is to be removed, so that they cannot inadvertently be plugged in and used). It is good practice before using electrical items to visually check that cords and connections have not suffered any physical damage.

Item and relevant AS/NZ Standard and/or Code of Practice	Frequency of testing	Person carrying out testing/inspection	Certification/Tag/Records	Comments
3. Emergency eyewash and shower equipment				
AS 4775:2007 *Emergency eyewash and shower equipment*	**Weekly visual inspection and weekly activation** *for a period long enough to verify operation and ensure that flushing fluid is available.* (6.8;7.6) *This weekly interval may be varied on the basis of a documented risk assessment.* (6.8;7.6)	A competent person such as member of science staff.	Weekly inspection records should be displayed near the eye wash/shower facility.	*NOTE: The intent is to ensure that there is a flushing fluid supply at the outlet of the device, to clear the supply line of any sediment build-up that could prevent fluid from being delivered to the outlet of the device and to minimize microbial contamination due to sitting water.* (6.8;7.6)
	Annual testing to ensure proper water flow rate and compliance with the requirements of AS 4775-2007.	A competent person such as a licenced plumber.	*A tag should be permanently attached to each eyewash/shower unit, to be marked at the successful completion of each inspection. (6.8;7.6)*	See also: • Emergency eye wash basins, showers and gas taps
4. Emergency stop buttons and isolation valves for power and gas				
AS/NZS 2982:2010: *Laboratory design and construction* *Model Code of Practice – Managing risks of plant in the workplace*	The Model Code of Practice states that: Control measures must be maintained so they remain *fit for purpose, suitable for the nature and duration of the work and are installed, set up and used correctly.* (p.19) Science ASSIST recommends **annual testing** of emergency stop buttons.	By in-house competent maintenance staff or outside contractors (e.g. electrician or gas plumber)	Records of inspections and servicing should be kept.	Any stop buttons or valves found not working optimally, should be reported immediately and warnings to be posted for the safety of the potential users. Emergency stops should be clearly labelled to indicate service and readily accessible. See also: • Testing emergency off buttons for power and gas

Item and relevant AS/NZ Standard and/or Code of Practice	Frequency of testing	Person carrying out testing/inspection	Certification/Tag/Records	Comments
5. Firefighting equipment				
AS 1851: 2012 *Routine service of fire protection systems and equipment*	**6 monthly inspection** The contractors should recharge used or non-compliant extinguishers immediately.	This is usually conducted school-wide by an outside licenced contractor. Some Australian state/territory jurisdictions may have legislative requirements for persons qualified to service portable fire extinguishers.	Each fire extinguisher and blanket is to be tagged to indicate compliance. This includes the date of testing. A summary record should be kept detailing the level of service and notes on any defects or issues.	Extinguishers need to be emptied, pressure tested and refilled every 5 years. Fire blankets are for single use only. Replace with a new blanket after use. See also: • SOP: Fire blankets • SOP: Use of fire extinguishers
6. Fume cupboards – built in, fully ducted				
AS/NZS 2243.8:2014 *Safety in laboratories, Part 8: Fume Cupboards*	**Annual testing and maintenance** is the minimum requirement.	A NATA accredited service provider.	*A self-adhesive label must be attached to the fume cupboard showing the inspection date, name of inspector and report number, overall test result (pass or fail), and the date on which the next inspection is due.* (5.5.4)	A fume cupboard that fails to pass the smoke test and/or the face velocity test should be taken out of use and signage used to indicate it is out of service. All faults require repair and the fume cupboard retested again before use. See also: • Fume cupboard servicing

Item and relevant AS/NZ Standard and/or Code of Practice	Frequency of testing	Person carrying out testing/inspection	Certification/Tag/Records	Comments
7. Fume cupboards – recirculating (these rely on inbuilt filters)				
AS NZS 2243.9:2009 *Safety in laboratories, Part 9: Recirculating fume cabinets*	*A maintenance schedule shall be developed to ensure that the performance checks are carried out regularly.* (7.1) according to the Standard's requirements.	*Testing shall be carried out by a competent person using equipment that has current calibrations that are traceable to standards of physical measurement in accordance with the National Measurement Act 1960 for Australia.* (5.2.6) e.g. a NATA accredited service provider.	*A copy of the siting requirements should be attached to the recirculating fume cabinet.* (6.2) *Records of performance checks shall be maintained in a logbook for each recirculating fume cabinet in use. These records shall indicate when pre-filters and main filters have been changed, and shall contain an accurate record of substances used in the cabinet, the volumes used, hours of operation and the occurrences of major spills or accidents, so that accurate predictions of future filter changes can be determined.* (7.2)	There are limitations associated with recirculating fume cupboards and users should be made aware of these limitations. **Science ASSIST does not recommend the use of recirculating fume cabinets in school science laboratories.** For more detailed information see: • AIS: Recirculating fume cabinets
8. Gas taps				
AS/NZS 2243.6:2010 *Safety in laboratories, Part 6: Plant and equipment* *Model Code of Practice – Managing risks of plant in the workplace*	Science ASSIST recommends **regular inspections** and at a minimum inspected annually.	By in-house competent maintenance staff or outside contractors (e.g. gas plumber)	Records of inspections and servicing should be kept.	Gas taps should be checked for leaks, blockages and smooth operation to maintain functionality and ensure safe operation. See also: • Emergency eye wash basins, showers and gas taps

Item and relevant AS/NZ Standard and/or Code of Practice	Frequency of testing	Person carrying out testing/inspection	Certification/Tag/Records	Comments
9. Safety glasses				
AS/NZS 1336:2014 *Eye and face protection-guidelines*	**Regular** inspections and cleaning. Systems should be in place for identifying and replacing damaged eye and face protectors.	To be carried out by a competent person	Records of inspections and cleaning should be kept.	Schools should establish systems for the provision and regular cleaning of safety glasses. Scratched / damaged safety glasses should be removed from use and be replaced. Use only non-abrasive cleaning agents and cloths. See also: • Safety glasses and assessing risks
10. Stepladders				
AS/NZS 1892.5:2000 *Portable ladders* *Model Code of Practice – Managing the risk of falls at work places*	**Pre-use inspection** before every use	To be carried out by the potential user.		Faulty ladders should be marked as faulty and removed from use. They should either be repaired by a competent person or destroyed so that they cannot be used. See also • AIS: use of stepladders in school science areas
	Regular inspections in accordance with the manufacturer's recommendations **and also** after mishaps, drops or impact.	A competent person such as a maintenance person.	Records of inspections should be kept.	

References and further reading:

[1] Standards Australia 2010, AS/NZS 2243.6:2010 *Safety in laboratories Part 6: Plant and equipment aspects*, 2.3 Requirement for safe conduct

[2] Standards Australia 2010, AS/NZS 2243.6:2010 *Safety in laboratories Part 6: Plant and equipment aspects*, 6.1 Maintenance general

[3] Standards Australia 2005, AS/NZS 2243.1:2005 *Safety in laboratories Part 1: Planning and operational aspects*, 1.4.2 Definition of Competent person

Standards Australia. 2000. AS/NZS 1892.5:2000 *Portable ladders*

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Standards Australia. 2010. AS/NZS 2243.6:2010 *Safety in laboratories: Plant and equipment*

Standards Australia. 2010. AS/NZS 3760:2010 *In-service safety inspection and testing of electrical equipment*

Standards Australia. 2010. AS/NZS 2982:2010 *Laboratory design and construction*

Standards Australia. 2012. AS1851.2012 *Maintenance of Fire Protection Equipment*

Standards Australia. 2014. AS/NZS 1336:2014 *Eye and face protection- guidelines*

Standards Australia. 2014. AS/NZS 2243.8:2014 *Safety in laboratories, Part 8: Fume Cupboards*

Standards Australia. 2014. AS/NZS 2243.10:2014 *Storage of Chemicals*

Standards Australia. 2017. AS1940:2017 *The storage and handling of flammable and combustible liquids*

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'Model Code of Practice: Managing risks of plant in the workplace', Safe Work Australia website, https://www.safeworkaustralia.gov.au/doc/model-code-practice-managing-risks-plant-workplace (25 May 2018)

'Model Code of Practice: Managing the risk of falls at workplaces', Safe Work Australia website, https://www.safeworkaustralia.gov.au/doc/model-code-practice-managing-risk-falls-workplaces (26 October 2018)

National Association of Testing Authorities, Australia (NATA) website http://www.nata.com.au/nata/

'Test and tag course', Workplace Health and Safety Electrical Safety Office Workers' Compensation Regulator | WorkCover Queensland website, https://www.worksafe.qld.gov.au/licensing-and-registrations/electrical-training/test-and-tag-course (Accessed November 2018)

WorkSafe WA. 2014. *Guide to testing and tagging portable electrical equipment and residual current devices at workplaces*, WA Department of Mines, Industry Regulation and Safety website, https://www.commerce.wa.gov.au/sites/default/files/atoms/files/guide-testing-and-tagging-portable-electrical-equipment-and-residual-current-devices.pdf

Science ASSIST resources

'Chemical Storage', Question to Science ASSIST, Science ASISST website, http://assist.asta.edu.au/question/2666/chemical-storage (17 February 2015)

'Chemical Store (ventilation)', Question to Science ASSIST, Science ASSIST website, https://assist.asta.edu.au/question/3145/chemical-store-ventilation (2 September 2015)

'Emergency eye wash basins, showers and gas taps', Question to Science ASSIST, Science ASSIST website, https://assist.asta.edu.au/question/3321/emergency-eye-wash-basins-showers-and-gas-taps (4 November 2015)

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'Testing emergency off buttons for power and gas', Question to Science ASSIST, Science ASSIST website, https://assist.asta.edu.au/question/2633/testing-emergency-buttons-power-and-gas (28 January 2015)

ASSIST INFORMATION SHEET:

Portable Bunsen burners

Portable Bunsen burners are sometimes used in school science areas where reticulated LPG or Natural Gas is not available; however, they lack the safeguards that reticulated services offer. This information sheet outlines design features of portable Bunsen burners and explores the safety issues that schools should consider (in conjunction with a detailed risk assessment) if they choose to purchase and use portable Bunsen burners.

Note: Some school jurisdictions do not permit the use of portable Bunsen burners.

Science ASSIST advises that a compliant reticulated gas supply MUST be used, where it is available, with traditional Bunsen burners. Science ASSIST discourages the use of portable Bunsen burners.

Gas Regulatory Authorities:

Communication with the Gas Technical Regulators Committee (GTRC) identified the following significant safety concerns with using portable Bunsen burners:

1. The lack of a central emergency shut off facility.
2. The requirement for proper storage and handling of the canisters.
3. The requirement for adequate safety training in their correct use.
4. The requirement for adequate adult supervision at all times whilst in use.
5. The requirement for users to be able to identify faults with individual units and manage the risks if a fault is identified.

GRTC advised that the use of a compliant reticulated supply must be used where it is available and recommended that in the absence of a reticulated gas supply an alternative **low risk**-heating source, such as using electrical heat, should be sought.

Science ASSIST:

- **advises that a compliant reticulated gas supply MUST be used, where it is available, with traditional Bunsen burners**
- **recommends** that in the absence of a reticulated service, schools use alternate heating options such as electric hotplates or hot water baths
- **recommends** that portable Bunsen burners should not be seen as a convenient alternative or a cost saving measure in schools with an existing reticulated gas service, or in a new or refurbished area where a reticulated service can be installed
- **recommends** that portable Bunsen burners should only be considered as a last resort for use as a heating source in demonstrations, subject to a risk assessment, in school science laboratories in situations where reticulated LPG or Natural Gas is not available and other forms of heating such as electric hotplates are not suitable for use.
- **recommends** that if portable Bunsen burners are deemed necessary, careful consideration be given to the type purchased and used. These should be of squat form for increased stability of

the burner with screw threaded valve resealing type gas canisters. They should be marked as compliant with Australian Standard 2278 or European Standard EN 417 and **designed specifically for use in science laboratories**
- **strongly advises against** the use of the puncture/pierceable style and spray/aerosol style canisters, due to several safety concerns
- considers that a compliant reticulated gas supply used with traditional Bunsen burners is not only safer, but in the long term also more economical than portable Bunsen burners.

Portable burners and gas canisters

There are a wide range of small portable gas cylinder burners available on the market. **Portable camping burners are designed for OUTDOOR USE ONLY and therefore indoor use of portable camping burners is prohibited.**

Portable burners use various types of disposable liquefied gas canisters, commonly a mixture of butane (80%) and propane (20%). All portable non-refillable gas canisters sold in Australia should comply with the Australian Standard 2278 (AS 2278), the European Standard EN 417, or both. This compliance should be marked on the canister. Do not purchase a canister that does not display this compliance.

There are three common types of non-refillable (disposable) gas canisters available in Australia.

1. **Screw thread and self-sealing canisters:** The top of the canister has a screw thread with a valve in the centre. The valve is commonly known as a 'Lindal' valve. The burner attachment can be removed with no escape of gas or risk of explosion, and the canister can be stored separate from the burner attachment. **It is recommended that only screw thread self-sealing canisters are used for portable Bunsen burners in schools**, and only in conjunction with burner attachments designed for science laboratory use. Canisters used for this purpose should be of low profile/ squat form so as to maximise stability.
2. **Puncture or pierceable gas canisters (C206):** The burner assembly is clamped on top of the canister and is used to puncture it. The potential for gas leakage is high with this type of canister, sometimes occurring when the puncture procedure is faulty or not performed correctly, or if the burner assembly is removed before the canister is empty. **As the pierceable canister has no valve or sealing mechanism, the canister cannot be safely removed from the burner until empty.** Removal prior to this has the potential risk of a fireball or explosion if the burner is in operation. Also, the cooling caused by the rapid loss of gas could cause 'cold' burns if the canister is being handled. These are **not recommended for school science use**.
3. **Spray can or aerosol canisters**: This type of canister uses the same principle as an aerosol spray paint or fly spray can. The burner assembly is used to depress the valve at the top of the can to release the gas. They are also not considered to offer the level of safety of the screw thread type canisters and are **not recommended for school science use**.

Other heat sources

Electric hot plates and water baths.

These are recommended as a lower risk source of heat for conducting activities.

Alcohol or spirit burners

These are NOT recommended as a general heat source for school science use. They comprise a clear glass bottle containing an alcohol fuel such as methylated spirits, and a screw fitted wick holder and wick. These pose some safety concerns. The screw fittings are usually not

spill proof if the burner is knocked over, and the flame of the burning alcohol is very pale and difficult to see. If they are not filled to more than half full they may become an explosion risk with the air/alcohol vapour they produce in the burner. They are occasionally used for comparing the 'heats of combustion' of different alcohols in calorimetry but are subject to a risk assessment.

Electric 'Bunsen burners'

These are not actually Bunsen burners, but electrically heated mantles, which radiate heat towards a central focal point. While they are designed as a safer alternative to Bunsen burners, they are very expensive, and generally not affordable by schools. See the link below for an example: http://www.labfriend.com.au/burners-1397

Considerations for the use of portable Bunsen burners

Although there is no legal requirement preventing the use of portable Bunsen burners in school science laboratories, Science ASSIST **strongly recommends that they be considered only as a last resort** in certain circumstances, preferably for demonstration purposes only and subject to a risk assessment. If portable Bunsen burners have been determined to be necessary, ensure that they are designed specifically for use in science laboratories and safe operating procedures and emergency response procedures are established prior to their purchase and use.

Safety concerns when using portable Bunsen burners in a school science laboratory

- **There is no 'single central' emergency cut off facility.** Each individual Bunsen is equipped with an on/off regulatory device.
- **There is no indication for 'on' or 'off' on the unit.** A threaded needle type valve fitting is utilised with a knob to turn it on, off or to control the gas flow. The gas flow can generally be heard when the unit is on.
- **The height of the portable Bunsen burner** requires a tall tripod, which can be unstable, to allow the item being heated to be at a suitable height above the flame of the burner.
- **Leaking of gas** from the canisters has occurred when using the puncture style canisters.
- **Safe storage** of the gas canisters is required.

Note: In contrast, in compliant reticulated gas installations, the following safety features apply:

- There is a master emergency gas shut off that can stop the gas to all appliances in the laboratory in the event of an emergency.
- Gas fittings usually have a turret with a lever, which clearly indicates when the gas is on.
- The height of the standard Bunsen burner uses a standard tripod, which offers more stability.

Design features to consider in a portable Bunsen burner

Portable Bunsen burners produce a single flame through mixing a flammable gas (LPG) with air and combusting it. They use a burner head with a control valve and an air intake control (collar) that attaches to a pressurised liquefied gas canister.

Design features to consider in a portable Bunsen burner for school science use should include the following features:

- A **gas control valve** that can be adjusted to regulate gas flow and flame intensity.
- An **air hole and mechanism to adjust air intake to obtain a yellow safety flame** like a standard gas plumbed Bunsen burner.

- A **reflective heat shield** mounted above the controls and the top of the barrel, to prevent undue heating of the controls and the gas canister. This safety feature not only improves performance but also prevents the burner heating the gas cylinder.
- The **ability to be lit with standard lighting procedures** using a match, a flint spark lighter or a gas flame lighter.
- The **canister is of squat form, with a screw thread fitting**, and a valve that seals the canister when it is disconnected from the burner.

Risk Assessment

The risk assessment should consider the maturity and skills of the class, the experience of the teacher, the degree of supervision, the place of use—teaching laboratory, preparation room, classroom, the number required and the frequency of use. Safety training in their correct use must be provided prior to handling.

Safety notes

- **Documented guidelines** should be established and carefully followed including; pre-use inspection, safe use procedures, student briefing process, maintenance, storage and disposal as per the manufacturer's instructions and local and jurisdictional requirements. **Adult supervision** must be provided at all times during use.
- Never leave the unit unattended under any circumstances.
- Burners and cartridges that are damaged should never be used.
- **Only teachers or technicians** should attach burners to cartridges. Users must be able to identify faults with individual units and manage the risks if a fault is identified.
- Care should be taken that the tripod and gauze supporting the item being heated is at a suitable height above the flame of the burner. The top of the burner should be greater than 10mm below the item being heated or below the gauze. It should also be easily removed from beneath the tripod.
- It is important to ensure ready access to the tap controlling the flame when the burner is under a tripod.
- As with other burner types, portable Bunsen burners should be used only in well-ventilated areas and away from flammable materials, using safe procedures.
- Never attempt to light a burner with another lit burner.
- Do not turn unit on its side or upside down.
- Ensure that the Bunsen burners are turned off after use.

Faults to look for to determine if an individual gas canister is unsafe to use

- Corrosion, dents, damaged seals.
- Leaks. Check with soapy water or look for frosting around suspect areas.
- Incorrectly fitted Bunsen burner.

Disposal of leaking or empty canisters

In the event of a leak, it is recommended that the leaking canister be moved safely to a fume cupboard or a safe area out of doors to allow the gas to dissipate completely away from any naked flames. The empty canister should then be disposed of according to local regulations.

Handling cold canisters

Canisters may 'ice up' in instances where there is prolonged use of the device.

Care should be taken when handling a canister in this condition. To reduce the risk of 'Cold burns', handle the canister wearing gloves designed for use at high or low temperatures.

Storage of Canisters when not in use:

- Total gas storage **must** comply with jurisdictional and local storage regulations.
- Canisters **must** be stored in a locked, cool, dark, separate, and well-ventilated area. Never store canisters in the sun. This may require the purchase of a suitable storage cage.
- Canisters **must not** be stored in damp areas, with or near corrosive materials, or with other flammable or combustible materials or near escape routes.
- Canisters must be stored in an upright position with the valve/cap closed.
- Monitor the canister for leaks after each use by checking the valve, cap, any seals and each part of the canister. Checking of leaks can be done with a soapy water mix, or looking for areas of frosting.
- Consideration needs to be given to the transportation of these units from the storage area to the lab and back.
- Spare cartridges should be stored away from those in use.

Further information on Bunsen burner safety

For more information on using Bunsen burners safely refer to the following websites:

- 'Standard Operating Procedure Using Bunsen burners', University of Sydney website, http://sydney.edu.au/science/molecular_bioscience/ohs/documents/sop/SOP%20SMB_006.2_Using%20Bunsen%20burners%20SK%20NC%200614.pdf (June 2014)
- 'Bunsen burner safety guidelines', Worcester Polytechnic Institute website, https://www.wpi.edu/offices/environmental-health-safety/laboratory/bunsen (Accessed January 2017)
- 'Laboratory Techniques: Using a Bunsen Burner', Mr-damon webpage, http://www.mr-damon.com/experiments/bunsen/ (Accessed January 2017)

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ASSIST INFORMATION SHEET:

Recirculating fume cabinets

Recirculating fume cabinets are an alternative to built-in fume cupboards, which have the benefits of portability, initial low cost and easy installation due to the absence of external ducting. They operate by drawing air into the cabinet and exhausting the air through a filtration and absorption system that removes chemical fumes and vapours before being recirculated back into the laboratory. There are however numerous limitations with this system and as a result Science ASSIST does not recommend their use in school science laboratories.

A recirculating fume cabinet may have an advantage of lower installation costs, however it is important that prior to considering purchase that a risk assessment is conducted to determine its suitability for its intended use. In the event of an existing fume cabinet being already on site, regular risk assessments should be conducted to ensure that current and future work has safe work practices in place. This should include aspects such as identification of the types and quantities of the airborne contaminants; the matching of appropriate filters with substances used and produced as well as the operational requirements of user safety through monitoring and disposal of saturated filters.

Recirculating fume cabinets should comply with **AS/NZS 2243.9.2009 Safety in Laboratories Part 9: Recirculating fume cabinets**.

This Standard specifies safety requirements and gives recommendations for the design, manufacture, use and maintenance of recirculating fume cabinets, the test methods to determine their performance and explains the limitations of their use.

The Foreword of the above Standard states:

> *Recirculating fume cabinets rely on filtration or absorption to remove airborne contaminants released in the cabinet, so that the exhaust air may be safely discharged back into the laboratory atmosphere. Recirculating fume cabinets are suitable for light to moderate use with a limited range of substances. The range of substances for which each cabinet can be used is limited by the need for compatibility with the particular type of absorber or filter fitted to the cabinet.* [1]

Science ASSIST recommendations

Science ASSIST does **not recommend** the use of recirculating fume cabinets in school science laboratories due to the following points.

1. **The filters are not suited for a wide range of chemicals**: Schools have access to a wide range of chemicals that are used in a variety of reactions producing fumes and gases requiring the use of a fume cabinet. Filters play a crucial role and are specific for groups of chemicals and hence the filter selected must be compatible with **all substances to be used.**
2. **Environment**: The filtration system can be affected by temperature and humidity.

3. **Siting location:** Fume containment can be affected by airflow disturbances so careful consideration needs to be given to the location of the cabinet.
4. **Possibility of hazardous vapours recirculating in the work environment**: There is potential for chemical vapours trapped in the filter to be released into the work environment when filter saturation has been reached, either through continual use or in the event of a chemical spill.
5. **Monitoring exhaust**: A system for identifying when filter saturation has occurred needs to be implemented so that occupational exposure standards for hazardous chemicals are not exceeded. School science laboratories are not generally sufficiently equipped to fulfil the requirements of monitoring and maintenance of filters and exhaust air quality on a regular basis. There is a large reliance upon the performance of these tasks as well as costs associated with this continuous maintenance and monitoring program.
6. **Disposal of filter:** Filters should be discarded and replaced when nearing chemical saturation. Used filters are regarded as hazardous waste and safe handling procedures need to be put into place for handling and disposal.
7. **Safe Operating Procedure:** Systems of work should be implemented to ensure that a competent person assesses all of the above matters. The absence of this could create a false sense of safety in the use of a recirculating fume cabinet.

A built in fully ducted fume cupboard, whilst more expensive for an initial set up, is recommended for school science use.

Limitations of recirculating fume cabinets:

1. General limitations on the range and amounts of substances which can be absorbed.

- Recirculating fume cabinets should be used for small quantities of low hazard chemicals
- They are not recommended for use with highly toxic or flammable substances
- They are not recommended for certain quantities of corrosive fumes
- Consideration also needs to be given to the atmospheric conditions.

Clause 2.2 of AS/NZS 2243.9.2009, Limitations of use [2]

The recirculating fume cabinet shall not be used in the following circumstances (see also Clauses 6.2, 6.6.2.3 and 6.6.2.4 in AS/NZS 2240.9.2009*):*

(a) For work with organic solvents which are only physically absorbed on the absorber and the solvents—

(i) have boiling points less than 75°C; and

(ii) are evaporated in quantities of more than 50 mL per day.

NOTE: Fumes from these organic solvents can be insufficiently delayed on the filter unless chemisorption takes place, i.e. a chemical reaction between the absorbent and the solvent fume.

(b) Where more than 50mL of corrosive liquids are involved in a reaction or process that generates fumes.

(h) Where temperature and humidity extremes can affect filter operation. See Section 5 of AS/NZS 2240.9.2009[2]

2. Siting of the recirculating fume cabinet

- The recirculating fume cabinet should be positioned and used in a well ventilated laboratory, taking into consideration traffic flow, doorways and egress.

- Airflow disturbances can have an adverse effect on fume containment and may lead to leakage of fumes into its surroundings.
- The surrounding temperature and relative humidity should also be considered since they may affect the filter performance.
- If the cabinet is mobile and is moved it requires testing to ensure optimal safe performance.
- For further details see AS/NZS 2243.9.2009 Section 5 Siting and Commissioning

3. Poisoning and saturation of the filter

- Filters play a vital role in the safe operation of recirculating fume cabinets.
- Filters are not suitable for all substances.
- A risk assessment needs to be conducted to ensure that the filter is suitable for the chemicals being used and this should be reviewed on a regular basis
- The fitted or selected filter will only be compatible with the fumes of the group of chemicals it is designed for.
- Reactions that produce unknown or incompatible products should not be conducted in a recirculating fume cabinet.
- When changing a task where the chemical/s used are changed or there is an alteration in the quantity, volume or frequency of use of the chemical/s the filter must be checked to ensure compatibility and to avoid unexpected filter saturation.
- Filters will become saturated after continual use or in the event of a significant spillage. If breakthrough occurs, hazardous substances will be recirculated into the laboratory.
- It is difficult to estimate the lifespan of a filter
- It is recommended to dedicate these fume cabinets for fixed tasks.

Clause 6.2 of AS/NZS 2243.9.2009, General procedures[3]

Recirculating fume cabinets shall only be used for absorbing the fumes that the fitted filter is designed for, and not for carrying out reactions that produce unknown products.

High concentrations of fume entering the filter can saturate the absorber.

Clause 6.6.2.3 of AS/NZS 2243.9.2009, Saturation of the filter[4]

The filter material has a limited capacity to absorb fume. This will vary with the particular chemical compound used and any previous or simultaneous exposure to other chemicals. Consequently, it is difficult to accurately predict the working life of the filter. Early detection of fume break through or filter saturation can be determined by checking for fumes on the exhaust side of the filter.

Clause 6.6.2.4 of AS/NZS 2243.9.2009, Poisoning of the filter[5]

The absorption of small amounts of some chemicals can have disastrous effects on the capacity of the filter system for other fume

These effects are impossible to predict, so that great care should be shown in using the recirculating fume cabinet for a wide variety of tasks. Recirculating fume cabinets should be dedicated to fixed tasks.

4. Monitoring and disposal of filters:

- There are specific procedures and costs associated with filter monitoring, replacement and safe disposal.

- It is imperative to have systems in place for regular checking of filters for saturation and efficiency and also for monitoring air quality of the exhaust. This is clearly described in detail under **clause 6.6 of AS/NZS 2243.9.2009, Identifying Filter Saturation**
- Safe operating procedures should be in place for the safe handling, replacing and disposal of contaminated filters.
- Used filters should be handled and disposed of as hazardous waste.

References

[1,2,3,4,5] These excerpts are from AS/NZS 2243.9.2009 Safety in Laboratories Part 9: Recirculating fume cabinets reproduced with permission from SAI Global Ltd under Licence 1407-c117

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ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEET:

Refrigerators and freezers in science

Refrigerators and freezers are generally a standard piece of school science laboratory equipment. Although not a mandatory requirement, having access to them is definitely useful.

Domestic refrigerators or freezers are commonly used in school science laboratories and may be used to store materials for dissections, certain chemicals, enzymes, microbial cultures, perishable items (foodstuffs) and ice for use only in science practical activities.

General operating conditions for refrigerators and freezers:

- Follow the manufacturer's instructions for proper siting location including provision of adequate ventilation and the need to keep away from heat sources.
- The optimal operating temperature for a refrigerator is the range of 0ºC–4ºC and for a freezer is minus 18ºC[1]. The temperature can be checked using suitable thermometers.
- Units should not be overfilled to allow cold air to effectively circulate to maintain even temperatures throughout.
- Freezers should be defrosted regularly to prevent ice build-up. This will allow for upright storage of containers and proper functioning. A frost-free model can be purchased instead.

Science ASSIST recommends the following:

- Refrigerators/freezers should be located in the science preparation area away from the chemical store, flammable liquids cabinet and any areas that are accessible by students.
- Food and drink for human consumption should never be stored in a laboratory refrigerator/freezer. Signage should be used to indicate this (See below).
- Flammable chemicals should never be stored in domestic refrigerators as they contain sources of ignition (See notes below). Signage should be used to indicate this (See below).
- Corrosive chemicals that produce corrosive vapours/fumes should not be stored in refrigerators due to the lack of ventilation and their ability to corrode metal.
- Incompatible chemicals should not be stored in the same refrigerator.
- Chemicals stored in refrigerators should be included in the annual stocktake, stored in closed containers and properly labelled with the contents, owner, date of acquisition or preparation and nature of any potential hazard. The labels used should be water resistant.
- Plastic trays can be used as secondary containment to capture spills.
- Regular housekeeping should be conducted to assess the condition of refrigerator/freezer contents. Check for cracked caps, blurred labels, old chemicals and any leaking chemicals. Leaks and spills should be cleaned up immediately. Units should be cleaned regularly, and stock be rotated to ensure that older items are used first.
- Dissection materials used in practical activities should be:
  - of good quality i.e. fresh and passed relevant health inspections
  - stored in the refrigerator when fresh for no more than 24–48 hours prior to dissection
  - wrapped individually or in class sets in air-tight packaging when freezing to enable easy defrosting and to avoid freezer burn. They should be frozen for no more than 12 months to maintain the quality of the material. Frozen material should be defrosted overnight in a refrigerator and used within 24 hours.

Signage

- There is no requirement to have the refrigerator/freezer locked, but it is recommended that appropriate signage is used such as 'No foodstuffs for human consumption to be stored in this refrigerator/freezer' to avoid contamination of food for human consumption[2] and 'Not suitable for flammable chemicals' to avoid storage of flammable chemicals[3].
- It is also recommended that signage, such as 'Do not turn off power' be placed near the power point to prevent accidental shutting off of the power. In the case of power outage, relevant contact details should be available to arrange alternate storage.

Considerations for storage of flammable chemicals

Domestic refrigerators have ignition sources within their electrical components and these include switches, internal lights, heating elements and motors. Due to the presence of ignition sources, flammable chemicals should never be stored in domestic refrigerators.

'Where flammable substances must be kept below room temperature, the refrigerators where they are stored must be spark-free to prevent ignition of the vapours inside. (Note that) Spark-free refrigerators are designed to eliminate generation of sparks inside the body of the unit only. These appliances within a chemical store are a source of ignition for flammable substances stored outside the refrigerator'[4].

Australian Standard 2243.2:2006 – *Safety in Laboratories Part 2 Chemical Aspects*, Section 4.4.3-part (c) states that: 'A refrigerator may be used to store flammable chemicals provided it has been designed and manufactured to eliminate ignition sources. It may be possible for a domestic refrigerator to be modified by a competent person to eliminate ignition sources.'[3]

Spark-free laboratory refrigerators and freezers are available from scientific suppliers. See the Science ASSIST School science suppliers list.

Note: Short term cooling of a flammable chemical can be achieved using an ice bath.

References and further reading

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[4] Science ASSIST. 2016. *Guidelines for the design and planning of secondary school science facilities in Australian schools*. https://assist.asta.edu.au/resource/4175/guidelines-design-and-planning-secondary-school-science-facilities-australian-schools, ASTA, p 24.

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ASSIST INFORMATION SHEET:

Use of stepladders in school science areas

'If ladders are used they must be selected to suit the task to be undertaken. In doing this, you should consider the duration of the task, the physical surroundings of where the task is to be undertaken and the prevailing weather conditions.

Ladders should have ***a load rating of at least 120 kg*** *and be* ***manufactured for industrial use'****.*[1]

Storage of items in school science areas is a common challenge. In most situations, it is impossible to avoid extending vertical storage or displaying items above head height. It has become a common practice to use stepladders in accessing/replenishing stored items or handling display items.

It is advisable to store lightweight items and rarely used items on higher shelves to minimise the risk of handling above head height storage using stepladders.

Science ASSIST recommends considering the information below as a general guideline when selecting, using and inspecting (maintaining) stepladders in science areas. It is the responsibility of employers to keep people safe when using ladders in the workplace.

Selecting a stepladder

- Choose a stepladder manufactured for industrial use with a minimum load rating of 120kg. Safe Work Australia does not recommend the use of domestic products in any Australian work place.
- Make sure a reputable manufacturer manufactures the stepladder/s to comply with *AS/NZS 1892.5:2000 Portable ladders Part 5: Selection, safe use and care.*
- Metal stepladders are not suitable when working with electrical power supplies or faced with any electrical hazard. A wide range of fibreglass stepladders is available when working with electricity.
- The length of the ladder should be appropriate for the maximum reach required (site specific decision).
- Extra-wide stepladders or platform stepladders are available for more stability and safety.
- Platform stepladders are/can be fitted with self-locking sprung castors (spring loaded castors) for ease of moving/handling a stepladder.

Before every use, **a pre-use inspection** should be carried out. **This should include a thorough inspection of the:**

- state or condition of the feet. If they are missing, worn or damaged the ladder could slip.
- stepladder platform. If the platform is split or buckled the ladder could become unstable or collapse.
- steps or treads on stepladder. If the steps are contaminated they could be slippery; if the fixings are loose on steps, they could collapse.
- locking device. It should be firm and secure when engaged.

The benefit of conducting pre-use checks is that they provide the opportunity to identify any immediate/serious defects before they cause an accident. It is advisable to regularly assess your entire site for potential fall hazards. Ensure all safety gear and equipment is in peak condition prior to use.

When using a stepladder to carry out a task:

- check that all four feet are in contact with the ground and the steps are level
- ensure it is on a surface that is firm, level, clear, dry and not slippery. Do not place on boxes, unstable bases or on scaffolds to gain additional height
- ensure it is fully opened and any locking devices are engaged
- try to position the stepladder to face the work activity and not side on
- carry only light materials and tools. Do not overload. Stepladders are meant for one person
- always face the ladder when ascending or descending
- don't stand and work on the top few steps unless there is a suitable handhold
- do not overreach. Move stepladder when needed
- avoid pushing or pulling stepladders from the side. Repeated sideways movement can make ladders unstable
- maintain three points of contact at the working position. This means two feet and one hand, or when both hands need to be free for a brief period ensure that two feet and the body are supported by the stepladder

Stepladders are to be used as a means of access to, or egress from, a work area and as a working platform for light work of short duration that can be carried out safely on a ladder only.

Inspection and maintenance

A competent person should regularly inspect stepladders in accordance with the manufacturer's recommendations. Ladders with any of the following faults must be replaced or repaired.

- Worn or damaged feet, including non-slip material.
- Stiles twisted, bent, kinked, crushed or with cracked welds.
- Rungs, steps, treads or top plates that are missing, worn, damaged or loose.
- Missing, loose, bent or worn fasteners, i.e. rivets, bolts and pins.

Single sided stepladder

Platform stepladder with sprung castors

References

[1] Safe Work Australia *Managing the risk of falls at work places – Code of Practice*, p 35, March 2015, Safe Work Australia website, http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/632/managing-risk-falls.pdf

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ASSIST INFORMATION SHEET:

Safe handling and use of potting mix

Students and/or staff in schools use potting mix as a nutrient rich growth media for plants. Potting mix is readily available from garden supply centres and horticultural nurseries or it can be prepared onsite using recycled organic products. Health concerns have been raised in the past, with gardeners contracting Legionnaires' disease. Other disease causing microorganisms may also be present in potting mix.

Ingredients of potting mix

There are many different commercially available potting mixes that are suitable for growing different plants. Manufacturers often source the ingredients locally so composition will differ from brand to brand, and location to location.

Composition of potting mix may include, but is not limited to:

- Peat
- Sand
- Perlite
- Vermiculite
- Zeolite
- Sawdust
- Wood chips
- Pine bark
- Plant mulch
- Top soil
- Wood dust
- Organic compounds or manure
- Mushroom compost
- A variety of non-specific living microorganisms including bacteria, fungi, protozoa
- Chicken manure
- Mineral fertilisers
- Wetting agent

It is important to obtain a current Safety Data Sheet (SDS) for the particular brand of potting mix you are using before starting work. A third party SDS can be used as supplementary information. See Science ASSIST answer to question on Third party Safety Data Sheets (SDSs)

Good quality potting mixes carry an Australian Standards Mark set of ticks. These potting mixes have been tested for drainage, water retention, water absorption, nutrients and pH. Premium potting mixes have a red tick and are suitable for long-term plants that require a better quality growth medium. Black ticks show regular standard potting mix suitable for short-term plantings such as annuals.[1]

PPE and safe handling and storage of potting mixes

The following precautions should be followed when using potting mix:

1. Read the warning on the bagged potting mix: *This product contains microorganisms.*
2. Always wear gloves. Standard duty gloves (AS/NZS 2161.1) are suitable.
3. Open the potting mix bag slowly and make sure that the opening is not directed towards your face.

4. Avoid generating and inhaling dust or mists from the potting mix. This can be avoided by ensuring it is kept damp while in use.

   Non-fogging dust resistant goggles or safety glasses (AS/NZS 1336:2014) can be worn if there is a risk of dust and/or liquid mist (bio-aerosols) getting into the eyes. If there is a risk of inhalation, wear a suitable particulate respirator (AS/NZS 1715 and 1716)[2]

   If working with potting mixes indoors or in greenhouses make sure that adequate ventilation is provided.

5. Wash hands thoroughly with soap after use.

Potting mix is considered to be stable when stored under conditions recommended by the manufacturer. Potting mix should be stored in the closed, original container in a dry, cool (15–25^{o}C), well-ventilated area out of direct sunlight.[3] Potting mix bags kept in direct sunlight can reach temperatures within the bag that become ideal for rapid growth of Legionella bacteria[4].

Under certain conditions such as direct sunlight, the rate of chemical breakdown may increase. Decomposition products such as ammonia, oxides of carbon, oxides of phosphorus and oxides of sulphur[5] may be present in minute quantities.

Diseases that can be contracted from potting mix

Legionnaire's disease

Legionnaire's disease is caused by gram-negative bacilli from the *Legionella* species. *Legionella* are generally acquired through inhalation of contaminated aerosols of water or of dust.[6] *Legionella longbeachae* often colonises potting mix and can be inhaled into the body when using potting mix, garden soils, mulch and compost causing lung infection or pneumonia.[7] There is a 2–10 day incubation period for Legionnaires' disease.[8] There is no direct human-to-human transmission.

A number of risk factors may increase the chance of developing Legionnaire's disease. These include:

- being above 50 years of age
- being a smoker
- being chronically ill
- having an impaired immune system
- taking steroid drugs.[9]

Few people who come in contact with Legionella bacteria actually develop the disease[10]. Children, pregnant women, the elderly, people with pre-existing conditions or immune-compromised people may be at particular risk of illness if exposed to potting mix. Healthy individuals are also known to develop disease from potting mix. School staff who have an increased risk, should ensure they carefully follow all prevention methods. All staff and students should seek medical advice immediately if they experience the following flu-like symptoms after working with potting mix:

- Headache
- Muscle aches
- Tiredness
- Chills
- Dry cough
- Shortness of breath

- Loss of appetite[11]
- Stomach pain and diarrhoea
- Sudden high temperature or fever

Pontiac fever

A milder infection than Legionnaire's disease, Pontiac fever has the symptoms of fever, chills, headache, malaise and muscle pain. These may be noticed between a few hours to 3 days after being exposed to the bacteria and last less than a week.[12] Pontiac fever has not been reported in Australia.[13]

Tetanus

Tetanus is a disease caused by a toxin of the bacteria *Clostridium tetani*, which affects the nervous system and often enters the body through minor puncture wounds or scratches.

Symptoms include muscle pain, difficulty swallowing, muscle spasms, convulsions and breathing difficulties. Further complications can include respiratory failure and cardiac arrest.

The bacteria can be found in soil, dust and manures. Tetanus can be prevented through immunisation. Gloves, sturdy shoes and long clothes should also be worn when exposed to potting mix and soil, as this will lessen the chance of wounds. Hands should be cleaned with soap and water after handling potting mix and soil.[14]

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[3] Yates, ibid.

[4] 'Dangers of Potting mixes', Daylilies in Australia website, https://www.dayliliesinaustralia.com.au/dangers-of-potting-mixes/ (Accessed January 2017)

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ASSIST INFORMATION SHEET:

Decontaminating microbiological equipment

Prompt and thorough decontamination of equipment used in microbiological activities is vital to protect staff, students and facilities from microbiological contamination. These procedures are suitable for the decontamination of Risk Group 1 microbes used in a Physical Containment level 1 laboratory.

Decontamination processes should commence during and immediately after a microbiology activity. Processes such as disposing of disposable items in bleach solution and wiping benches with 70% v/v ethanol after an activity is completed are implemented to contain any microbes and stop the transmission to students and staff in the following lab sessions.

Provide containers with relevant solutions and contaminated waste bags e.g. autoclave bags or oven bags for students to segregate and dispose of equipment and cultures. Each receptacle should be labelled with its function. Ensure these are removed from the laboratory at the end of the activity.

Procedure for using an autoclavable biohazard or oven bag for sterilising microbiological waste:

- **Loosely pack microbiological waste including agar plates into bags to no more than 2/3 full**. This will ensure that the steam during sterilisation will penetrate the entire load. Bags that are tightly filled to capacity will not allow effective steam penetration and the contents will not be sterilised even if all sterilisation parameters are met.
- **Make sure there are no sharp objects present** that may puncture the bag.
- **Loosely tape shut the bag leaving an opening of about 5–6cm** to allow good steam penetration. This can be done with autoclave tape or a rubber band. Never tightly close the bags as they are impervious to steam and therefore the temperature of the inside of the bag will not be sufficient for sterilisation.
- It is advisable to **place the bag into a secondary container** within the steriliser to prevent any leakage into the steriliser should the bag rupture. The container must be able to withstand the autoclaving conditions.
- **Do not overload the steriliser** with too many bags as this may block steam circulation.
- **Use a sterility compliance strip** to indicate if the correct time, temperature and pressure have been reached during the run time. These are available from scientific suppliers.
- **Sterilise at 15psi, 121^{o}C for 15–20 minutes.**
- After sterilisation has been verified, the autoclave or oven bag containing waste items should be **disposed of by placing it into a sturdy garbage bag which is sealed for immediate disposal in industrial bins.**
- **Wear heat protective gloves** when removing waste from the steriliser.

See table over the page for suggested decontamination techniques.

References

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CONTAMINATED Item	Suggested decontamination technique
Inoculated agar plates – plastic	Pack unopened plates loosely in an autoclave bag, leaving an opening of about 5–6cm to allow good steam penetration. Autoclave at 121°C, 15psi for 15–20mins. When cool, place unopened autoclave bag in a garbage bag and dispose in general waste.
Inoculated culture broth in McCartney or Bijou bottles.	Make sure that the lids are loose. Autoclave at 121°C, 15psi for 15–20mins. Empty contents in the sink with copious amounts of water. Wash in warm soapy water, rinse well and dry. *Resterilise:* Re-autoclave loosely lidded container. Store in a clean closed container.
Inoculated water in glass bottle	Make sure that the lids are loose. Autoclave at 121°C, 15psi for 15–20mins. Empty contents in sink. Wash in warm water and dry. *Resterilise:* Re-autoclave loosely lidded container. Store in a clean closed container.
Plastic dropping pipettes	1) Soak in 0.5–1% sodium hypochlorite solution to sterilise for a minimum of 2 hours. After soaking discard into the general waste, or 2) Place directly into an autoclave or oven bag located on the student's bench space and autoclave at 121°C, 15psi for 15–20mins. When cool, place unopened autoclave bag in a garbage bag and dispose in the general waste.
Used swabs	1) Soak in 0.5–1% sodium hypochlorite solution to sterilise for a minimum of 2 hours or. After soaking discard into the general waste, or 2) Place directly into an autoclave or oven bag located on the student's bench space and autoclave at 121°C, 15psi for 15-20 mins. When cool, place unopened autoclave bag in a garbage bag and dispose in the general waste.
Sterile 'L' spreader	1) Soak in 0.5–1% sodium hypochlorite solution to sterilise for a minimum of 2 hours, or 2) Place directly into an autoclave resistant container and cover with foil or place into an autoclave/oven bag located on the student's bench space and autoclave at 121°C, 15psi for 15-20 mins. 3) After sterilisation, wash in warm soapy water, rinse and dry. *Resterilise:* Wrap in foil and sterilise in an autoclave or hot air oven. Store until required for re-use.
Sterile forceps	Carefully place into an autoclave resistant container such as a large test tube, cover with foil and autoclave. Wash in warm soapy water, rinse and dry. *Resterilise:* Wrap in foil or place inside a clean test tube, cover opening with foil and autoclave, Store until required for re-use.
Test tubes	Autoclave at 121°C, 15psi for 15–20mins. Empty contents in sink. Wash in warm soapy water, rinse and dry. *Resterilise:* Plug with non-absorbent cotton wool and autoclave or cover the opening of the test tubes with foil and sterilise in a hot air oven or autoclave. Store in a clean closed container.

CONTAMINATED Item	Suggested decontamination technique
Inoculating loop	Flame to red heat carefully in the blue flame of the Bunsen burner to prevent the transmission of aerosols. Cool and reuse immediately. Alternatively, if using disposable inoculating loops, 1) Soak in 0.5–1% sodium hypochlorite solution to sterilise for a minimum of 2 hours.. After soaking discard into the general waste, or 2) Place directly into an autoclave or oven bag located on the student's bench space and autoclave at 121°C, 15psi for 15–20mins. When cool, place unopened autoclave bag in a garbage bag and dispose in general waste.
Susceptibility discs Mastrings (set of 6 or more antibiotic discs joined together)	Susceptibility discs and Mastrings should remain on the agar plate after examination. The agar plate remains closed. Pack unopened plates loosely in an autoclave bag and autoclave at 121°C, 15psi for 15–20mins. When cool, place unopened autoclave bag in a garbage bag and dispose in general waste.
Paper towel exposed to contaminated areas Used disposable aprons/lab coats Used gloves	If not soaked in bleach or alcohol, sterilise in an autoclave or pressure cooker. If soaked leave for the recommended time and then dispose of into the general waste. An autoclave or oven bag should be placed in the laboratory for students to place these waste items directly into the bag. Do not overfill the bag. Leave an opening of about 5–6cm to allow good steam penetration and sterilise for 15–20 min at 121°C and 15psi. Place the unopened autoclave bag into a sturdy garbage bag and seal for immediate disposal in an industrial bin.
Laboratory benches Plastic containers used for storage and distribution of equipment Any other hard surface	Dilute disinfectant in fresh water according to the manufacturer's instructions. Use in a spray bottle. Dilute ethanol to 70% in fresh water, use in a wash bottle. Ethanol is flammable. Apply liberally to laboratory bench or other hard surface to be decontaminated. Wipe lightly with paper towel. Allow the residual to air dry.

ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEET:

Preparing sterile equipment for microbiology

Equipment used in microbiology should be sterile before using. This enables aseptic techniques to be used when transferring microorganisms for inoculation, sampling environmental areas, adding susceptibility discs to agar plates and Gram staining.

This equipment should be prepared before the class activity and stored in clean, lidded containers.

Equipment such as hockey stick spreaders, inoculating loops and sterile swab sticks can be purchased as single-use items from commercial scientific suppliers if the school budget allows or it is more time effective to do so.

In-house preparation of sterile items is cost effective to schools as some pieces of equipment can be repeatedly recycled. Care should be taken with ethanol as it is a flammable substance and should not be used near a naked flame.

Considerations:

- Sterilisation of equipment should be performed in a draught-free area.
- Items to be sterilised should be clean and dry, metal forceps should not be rusty, glass items should not have chips or cracks.
- Consult the planned activity or activities prior to sterilising items to ensure there is the required number of items available during the activity.
- Ensure the bench area for this purpose has been decontaminated with 70% ethanol prior to commencing.
- Soaking items in a container of 70% (v/v) ethanol for 10 minutes, disinfects/decontaminates, but does not sterilise items. Alcohols are not sporicidal.
- Aluminium foil or greaseproof paper may be used to wrap sterile items.
- Sterile items can be stored in a large lidded plastic container that has been decontaminated with ethanol and paper towel.
- **Glassware and metal instruments can be wrapped in aluminium foil and sterilised using dry heat in an oven at 160°C for 2–3 hours.**
- **All sterilising processes using an autoclave/steriliser or pressure cooker should be at 121°C for 15–20 minutes at 15psi (pounds per square inch of pressure).**
- Professional microbiologists and higher education providers promote the sterilisation technique of ‘flaming’ hockey stick spreaders and forceps prior to using by dipping in 70% ethanol and igniting it in the Bunsen flame. Incorrect techniques can encourage microbial aerosol transmission and risk the ethanol catching on fire. **Science ASSIST does not recommend this practice in the school setting, but instead recommends sterilising these items in an autoclave or an oven.**

Item	Suggested sterilising technique	Alternative technique
Sterile plastic Petri dishes	Purchase sterile, leave wrapped in original packaging until required. (Do not autoclave prior to use. Plates do not retain shape when autoclaved.)	
Sterile glass Petri dishes	Wrap glass Petri dishes in greaseproof paper or aluminium foil and sterilise in an autoclave	Wrap in aluminium foil. Sterilise using dry heat in an oven at 160°C for 2–3 hours
Nutrient agar plates	Prepare agar solution according to the manufacturer's instructions, autoclave in a heat-safe bottle with lids loose and pour plates when temperature of sterile agar is ~50^0C using aseptic technique. When set, wrap in plastic wrap. Store at 4°C until required. See ASSIST SOP: Preparing agar plates	Purchase prepared and sterile from a biological supplier
Nutrient broth	Prepare broth solution according to the manufacturer's instructions. Aliquot ~15mL into McCartney bottles (28mL capacity) keep lids loose. Autoclave. When cool tighten lids and store at 4°C until required.	Purchase prepared and sterile from a biological supplier
Sterile water	Aliquot 2mL into Bijou bottles (7mL capacity) keep lids loose. Autoclave. When cool tighten lids and store at 4°C until required.	
Sterile plastic dropping pipettes	Purchase single-use pipettes from commercial scientific, biological or medical suppliers.	
Sterile swab stick	Purchase sterile, leave wrapped in original packaging until required.	Autoclave cotton buds in foil covered beaker.
Sterile 'L' spreader	Wrap in aluminium foil and autoclave. Store until required.	Wrap in aluminium foil. Sterilise using dry heat in an oven at 160°C for 2-3 hours.
Sterile forceps	Wrap in aluminium foil or place inside a clean test tube, cover opening with aluminium foil and autoclave. Store until required.	Wrap in aluminium foil. Sterilise using dry heat in an oven at 160°C for 2-3 hours.
Sterile test tubes/ conical flasks	Cover opening with foil or plug with non-absorbent cotton wool. Autoclave.	Cover opening with aluminium foil. Sterilise using dry heat in an oven at 160°C for 2–3 hours
Inoculating loop	Flame to red heat in the blue flame of the Bunsen burner.	Purchase sterile disposable inoculating loops, leave wrapped in original packaging until required.

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ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

ASSIST INFORMATION SHEET:

Microwave, pressure cooker or Autoclave? Recommendations for best practice of sterilising agar.

Preparation of agar plates is central to effectively and economically expose our students to the wonderful world of micro-organisms. School science labs have long questioned the best physical method of control to sterilise agar prior to pouring into Petri dishes. Methods used for sterilizing include pressure cookers, sterilisers or autoclaves. Most schools have limited financial resources available, and sourcing processes and equipment that are cost effective is a priority. So which method should you choose and why?

Sterility of processes and equipment forms the very essence of good microbiological laboratory practice and the teaching of these methods to students. This includes the preparation and presentation of agar plates and other equipment used either before, during or after the practical has been run. Teaching aseptic technique to students can be part of the unit of learning; however can be a difficult process to master for first timers. Outcomes of student practicals may be misleading or incorrect if external contaminates are introduced at any stage prior to or during inoculation. Unfortunately, this is often not evident until much time and effort by the student and lab technician has passed and the results are interpreted. Ascertaining the source of any contaminant can be difficult and inconclusive.

While many types of agar plates are available commercially, many laboratory technicians prepare plates in-house thus reducing the cost to schools. Although it can be time consuming, many schools find the cost benefit far outweighs time spent. Many school science preparation areas are used for many disciplines of science and are not usually specific to microbiology or necessarily a 'clean' area. Schools may be permitted by their state jurisdictions to use micro-organisms from Risk Group 1* and/or culture environmental samples. It is impossible to predict what, if any, further contaminants may be introduced to an agar plate during a practical session. Hence the need to 'get it right' by initial effective sterilisation of agar to ensure plates distributed to students do not contain any contaminants.

Universally, micro-organisms are ubiquitous. Effective sterilisation of a liquid such as agar is achieved when all viable organisms are eliminated[1]. The most effective and suitable method of sterilising agar is by using moist heat in the form of steam under pressure i.e. 121^{o}C for 15 minutes at 15 pounds per square inch (psi). This method will denature & coagulate enzymes and other cell constituents in the bacterial cell. Sterilization can be guaranteed only when these parameters are reached.

Sterilisation of agar and plates is usually done in an autoclave or a commercially available pressure cooker with a gauge and the capacity to reach 15 psi, which provides these conditions. Microwave ovens will not sterilise as they do not provide these conditions and therefore are not a suitable alternative to a pressure cooker or autoclave. Water boils at 100^{o}C at atmospheric pressure, but if pressure is raised, the temperature at which the water boils also increases. In an autoclave or pressure cooker the water is boiled in a closed chamber. As the pressure rises, the

boiling point of water also raises. At a pressure of 15 psi inside the autoclave, the temperature is said to be 121°C. Exposure of articles to this temperature for 15 minutes sterilises them.[2]

Due to the action of a microwave oven, micro-organisms will not be killed. Microwaves penetrate unevenly and there are also 'hot spots' caused by wave interference. The whole heating process is different because you are 'exciting atoms' rather than 'conducting heat'.[3] The heat and pressure required to effectively sterilise agar will be insufficient and cannot be maintained for the required period of time. The agar will boil over before any of the required parameters are reached.

As laboratory technicians, we are constantly on the lookout for more efficient ways of finding good quality relevant resources for our students and teachers within budgetary constraints. Sourcing equipment such as a pressure cooker or autoclave is important to ensure the validity of student results and is imperative for microbiological safety.

***WHO Risk Group 1** (no or low individual and community risk). A micro-organism that is unlikely to cause human disease or animal disease (AS 2243.3)

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LABORATORY NOTES:

Food tests

Food testing is routinely carried out in senior biology classes. Students test a variety of food samples for carbohydrates, such as sugar and starch; lipids; proteins and vitamin C. These organic compounds react with specific chemical reagents to produce a visible and identifiable change.

Safety note:
Food or drink used in science laboratories must never be consumed as they may be contaminated.

A word of caution:
It is good practice to use the least hazardous test where available. Science ASSIST recommends the tests listed below as suitable for use in schools. There are, however, several food test methods that require the use of more hazardous chemicals, which should only be used following a site-specific risk assessment. There are some food testing procedures that are too hazardous and **must not** be used in schools. For example, Millon's reagent, which tests for proteins, contains mercury compounds. Biuret reagent is a much safer alternative.

Testing for vitamin C in foods

Vitamin C also known as L-ascorbic or ascorbic acid is a water-soluble vitamin. It is naturally present in a variety of fruits and vegetables and is also a dietary supplement. Sources include oranges, strawberries, red capsicums, blackcurrants, broccoli and Brussel sprouts. Vitamin C is also a reducing agent.

An indicator called DCPIP (2, 6-dichlorophenolindophenol) can be used to test for the presence of vitamin C in foods. DCPIP will change in colour from blue to red in the presence of an acid but loses its blue colour in the presence of vitamin C.

Materials:

- Food samples that contain vitamin C
- 0.1% ascorbic acid
- 0.1% DCPIP solution in a dropper bottle
- Test tubes
- Dropping pipette
- Deionised/distilled water

Method:

- Add 2mL of 0.1% DCPIP solution to a test tube.
- If using a liquid such as orange juice, add it drop by drop to the DCPIP solution in a test tube, mixing after each drop is added.
- When testing solid foods a liquid sample should be prepared by crushing the food in some deionised/distilled water and using only the liquid in the test procedure.
- Add the liquid sample drop by drop to the DCPIP solution in a test tube, mixing after each drop is added.
- The colour will change from blue to red if the sample is acid.
- Continue to add more of the test sample and if the colour of the DCPIP disappears then it shows that vitamin C is present.
- The 0.1% ascorbic acid is used as a positive control and a water sample as a negative control.
- This activity can be extended to utilise a titration method to determine the amount of vitamin C present in a food sample.

Testing for protein in foods

Gelatine is a protein derived from animal tissues such as skin and bone.

The Biuret test is used to detect the presence of peptide bonds in proteins. It can be carried out in several ways:

1. Addition of a Biuret reagent.
2. Addition of sodium hydroxide and copper sulfate solutions.

If protein is present, the solution turns from blue to purple due to the complexing of copper II ions with the peptide bonds in the protein sample. The more peptide-copper complexes that are formed, the deeper the purple colour.

Note: Test strips can also be used to detect some proteins. For example, Albustix or Uriscan.

A 1% w/v gelatine solution freshly prepared is generally used in the school science laboratory for a positive control. Deionised water can be used as a negative control.

Materials

- 1gm gelatine
- Biuret reagent or 2M sodium hydroxide and 1% w/v copper sulfate solutions
- 100mL deionised or distilled water
- Stirring rod
- Test tubes
- Electronic balance
- Spatula
- 1mL pipette

Preparation of a 1% w/v gelatine solution

- **Weigh out 1gm of gelatine powder.**
- **Add to 100mL of deionised/distilled water in a beaker.**
- **Warm to around 50˚C and stir to dissolve.**
- **Cool to room temperature before use.**

Method

- Add 1mL of the 1% w/v gelatine solution to a test tube.
- **Method 1:** Add 1 mL of the Biuret solution OR,
- **Method 2:** Add 0.5mL 2M sodium hydroxide solution followed by 0.5ml dropwise of the 1% w/v copper sulfate solution.
- For both methods mix and allow to stand for 5 minutes.
- Observe a colour change from blue to purple indicating the presence of protein.

Note: When testing foods, prepare a liquid sample by crushing the food in some deionised/distilled water and using only the liquid in the test procedure.

Testing for glucose (a reducing sugar) in foods

All monosaccharides and some disaccharides are reducing sugars. Some examples are glucose, fructose and lactose.

Benedict's solution is used to test for the presence of reducing sugars. The copper (II) ions present in Benedict's solution are reduced by these sugars to an insoluble brick-red copper (I) oxide, which precipitates. The blue colour will first turn green, then yellow and may finally form a brick-red precipitate. The amount of reducing sugars present can be related to the amount of precipitate formed. Test strips can be used to test solely for the presence of glucose.

A 1% w/v glucose solution freshly prepared is generally used in the school science laboratory for a positive control. Deionised water can be used as a negative control.

Materials

- 1g glucose powder
- Electronic balance
- Spatula
- Stirring rod
- 1mL pipette

Method 1: Test for glucose

- Test strips (such as Diastix, Clinistix, Uriscan or similar, available from pharmacies)

Method 2: Test for reducing sugars

- Benedict's solution in a dropper bottle
- 100mL deionised or distilled water
- Bunsen burner, tripod and gauze
- Test tubes
- 250mL beaker
- 400mL beaker half filled with tap water for use as a water bath

Preparation of a 1% w/v glucose solution

- **Weigh out 1gm of glucose powder.**
- **Add to 100mL of deionised/distilled water in a beaker.**
- **Stir to dissolve.**

Method 1

Follow the instructions for the test strips:

- Dip the test strip into the solution and wait the required time.
- Compare the colour chart with the test strips to determine the presence of glucose.

Note: The strips can be cut into half lengthways to obtain double the use.

Method 2

- Add 1mL of the 1% w/v glucose solution to a test tube.
- Add 1mL of Benedict's solution and mix.
- Place the test tube into a beaker containing boiling water.
- Boil gently for 2 minutes.
- Observe colour change and any precipitate formed.
- A brick-red precipitate indicates a positive result for the presence of a reducing sugar such as glucose.
- When testing solid foods for the presence of a reducing sugar add a small amount of the food into a test tube and cover with Benedict's reagent then heat gently for 2 minutes in a boiling water bath.

Testing for starch in foods

Starch is a complex carbohydrate found in a wide range of foods such as potatoes, rice, corn, pasta and grains. It is a mixture of the polysaccharides amylose and amylopectin, which vary in concentration depending on the type of starch used. Starch will produce a colloidal solution in water as it is not very soluble. Iodine solution is used to test foods for the presence of starch. If starch is present it will react with the iodine solution to produce a blue/black starch-iodine complex.

A 1% w/v starch solution is generally used in the school science laboratory for a positive control. The intensity of the colour produced when iodine solution is added is related to the concentration of the starch solution. The higher the concentration of the starch solution, the more intense blue/black complex is formed. The weaker the starch solution then a brown colour is produced. Deionised water can be used as a negative control.

It is best to prepare a fresh starch solution on the day that it is required as it deteriorates quickly.

Materials

- 1g starch (e.g. cornflour, potato flour or rice flour)
- 100mL deionised or distilled water
- Hot plate or Bunsen burner, tripod and gauze
- Electronic balance
- Spatula
- 250mL beaker
- 100mL measuring cylinder
- Stirring rod
- Test tubes or spotting tray
- Plastic Petri dish
- 1mL pipette
- Iodine solution (0.3% w/v iodine in 1.5% w/v potassium iodide) in a dropper bottle

Preparation of a 1% w/v starch solution

- **Prepare a smooth paste of 1gm of starch with a small volume (a few millilitres) of deionised/distilled water.**
- **Bring to the boil 100mL of deionised/distilled water.**
- **Add the starch paste to the boiling water and stir until dissolved. The solution will be cloudy in appearance.**
- **Allow to cool before use.**

Method

- Add 1mL of the 1% w/v starch solution to a test tube
- Add 2-3 drops of iodine solution
- A blue/black colour indicates a positive result (the formation of the starch-iodine complex).
- Alternatively, a few drops of the starch solution can be added to a well of a spotting tray and 1-2 drops of the iodine solution added.
- When testing solid foods for the presence of starch add a few drops of the iodine solution directly to the food in a plastic Petri dish.

Testing for the presence of lipids in foods

Lipids consist of fats and oils that are soluble in organic solvents, such as ethanol, but insoluble in water. Lipids are made up of fatty acids and glycerol. There are several ways to detect the presence of lipids in a food sample. Commonly used are the Ethanol Emulsion Test and Grease Spot Test.

A vegetable oil sample is generally used in a school science laboratory as a positive control. Deionised water can be used as a negative control.

Materials:

- Vegetable oil
- Food sample containing lipids, e.g. milk, cream, cheese or yoghurt

Method 1: Ethanol Emulsion Test

- Ethanol
- Pasteur pipette or dropper
- Test tubes
- Deionised/distilled water

Method 2: Grease Spot Test

- Brown paper bag strips approximately 10 x 5cm
- Cotton buds
- Light source such as a lamp
- Knife to cut solid pieces of food samples

Method 1:

- Combine 20 drops of the oil or liquid food sample with 2mL of ethanol in a test tube.
- Mix well. Allow to settle for 2 minutes to allow any lipid present to dissolve in the ethanol.
- Add 2mL of water directly to this tube and mix gently.
- If using a more solid food sample, first allow any particles to settle, then remove the clear liquid component into another test tube containing 2mL of water and mix gently.
- The solution will turn a cloudy white colour if lipids are present. Any lipids in the sample precipitate in the water forming an emulsion.
- Water can be used as a control. In this case no white emulsion is observed indicating there are no lipids present.

Method 2:

- For oil or liquid food samples apply a small amount to a cotton bud and swab directly onto a piece of brown paper bag.
- For more solid food expose a freshly cut surface and rub this on a piece of brown paper bag.
- Apply a water sample with a cotton bud to another piece of brown paper bag.
- Allow to dry for around 5 minutes.
- Hold the piece of paper bag up to a light source and look for a translucent spot that will indicate that lipids are present.
- If the sample applied evaporates without leaving a translucent spot then no lipids are present.

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LABORATORY NOTES:

Generation and collection of nitrogen dioxide (NO_2) gas for equilibrium demonstration

Nitrogen dioxide gas is used to demonstrate Le Chatelier's principle of equilibrium. The gaseous equilibrium is a mixture of nitrogen dioxide, a brown to reddish brown gas, and dinitrogen tetroxide, a colourless gas, and is represented by the chemical equation

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$
(colourless) (brown)

Two main effects are demonstrated:

1. The effect of temperature, where a fixed volume of gas is observed at different temperatures.
2. The effect of pressure, where gas is collected in a syringe and compressed.

The effects can be observed in the change in the colour of the gas.

Safety and technical notes:

The preparation and handling of nitrogen dioxide should only be conducted in an operating fume cupboard by trained staff, wearing appropriate PPE.

PPE: safety glasses, closed shoes, laboratory coat, nitrile gloves. (Note: Viton®, butyl, neoprene provides protection for prolonged direct exposure to nitric acid. Nitrile is acceptable for splash contact with nitric acid. Gloves should be removed, hands washed and new gloves put on in the event of splash contact).[1,2]

Nitrogen dioxide is a brown gas with a pungent, acrid odour. It is a toxic, corrosive gas and a strong oxidising agent, which supports combustion. Exposure may cause severe irritation to the skin, eyes and respiratory tract. Inhalation of low concentrations can cause lung damage. Inhalation of high concentrations can lead to pulmonary oedema, which can be fatal; the effects can be delayed. Inhalation of NO_2 can aggravate respiratory conditions such as asthma.[3]

Preparation involves the use of concentrated 70% (not fuming) nitric acid.

Concentrated (70%) nitric acid is highly corrosive and a powerful oxidant and should be handled with care. Exposure may cause severe irritation and burns to the skin, eyes and respiratory tract and on ingestion. Eye contact may result in severe eye damage and permanent injury. Handle only in an operating fume cupboard, do not breathe vapour or mist, avoid contact with skin, eyes and clothing and avoid any prolonged or repeated exposure. Handle away from heat and sources of ignition.[1]

Handling nitric acid: It is best practice to use a spill tray under your work and to use a glass pipette, although a polyethylene pipette is acceptable for limited use when the acid is cold. Pour a small quantity into a small beaker. Use a glass pipette (Pasteur or graduated) to deliver the nitric acid into the flasks. Do not remove open vessels containing concentrated acid from the fume cupboard into the open lab. Any glassware or other equipment, which is contaminated with concentrated acid, should be rinsed with water before removal from the fume cupboard. Any unused concentrated acid should be diluted by addition to water before being removed from the fume cupboard.

Stoppers and flexible tubing: Silicone is preferred over rubber, which is adversely affected by NO_2

Syringes: It is essential that syringes are of good quality and have a Luer lock tip. The Luer lock tip enables a cap to be fitted to prevent the gas from escaping.

- Glass syringes are preferred because they are transparent and it is easier to see the colour of the gas. A small amount of vacuum grease can be applied to the plunger to minimise the potential loss of NO_2 gas.
- If using plastic disposable syringes, these MUST be new to ensure that the rubber tips on the plungers have not been degraded.

Generation of NO_2 gas directly in a flask for a demonstration to observe the effect of temperature

The generation of nitrogen dioxide gas occurs as a result of the reaction of nitric acid on copper metal, usually in the form of small pieces of copper turnings or copper foil.

We can estimate the volume of gas we require and use a limited quantity of nitric acid given that '8 ml of concentrated nitric acid produces 1000 cm^3 of nitrogen dioxide at room temperature and pressure'.[4]

To make three flasks of NO_2 gas:

Materials:

- 3 x 250mL round bottom flasks with well-fitting stoppers, preferably Quickfit® style (alternatively a flat bottom flask could be used, again with well-fitting stoppers)
- For each flask, about 0.5 gram of copper turnings or 3 small pieces of copper foil about $5mm^2$
- For each flask, about 2mL of concentrated (70%) nitric acid
- Glass Pasteur or graduated 2–3mL pipette
- Ice water bath
- Warm water bath (60–70°C)

Procedure:

In a fume cupboard place the copper foil/turnings into each of 3 flasks; using a pipette, add the nitric acid to the flask and then stopper the flasks.

Once stoppered the flasks can be taken out of the fume cupboard and used in the classroom as a demonstration.

The three flasks should then be put into three different temperatures and any colour changes observed. The use of a white background enhances the visibility of the colour changes.

- Ice water bath: The gas contracts and becomes paler in colour as the equilibrium shifts to the left adjusting to the decrease in temperature.
- Room temperature: This is the control; there should be no colour change.
- Warm water bath, approximately 60–70°C: The gas expands and becomes darker as the equilibrium moves to the right adjusting to the high temperature.[6]

When the demonstration has finished, simply return the flasks to the fume cupboard, then either unstopper the flasks, allowing the gas to dissipate, or simply dilute the residual mixture with water. Decant the solution from any residual copper metal, neutralise the solution to within pH 6–8 and wash to waste. The copper metal can be rinsed and recycled or disposed of with general waste.

Generation and collection of NO_2 gas into test tubes and syringes

Materials:

- 1 x 250mL Büchner flask with a side arm with a short length of flexible tubing, or 1 x 250mL round or flat bottom flask with a one-hole stopper with a glass delivery tube with flexible tubing
- The tubing connection between the flask and the syringe should be gas-tight. This can be achieved by using two lengths of tubing, one with an internal diameter that fits onto the connection at the flask and one that fits onto the tip of the syringe. A reducing tubing connector[5] can be used to connect the two lengths. The tubing may need to be softened by briefly placing in boiling water before attaching.
- About 1 gram of copper turnings or 6 small pieces of copper foil about $5mm^2$
- About 4mL of concentrated (70%) nitric acid (to produce about 500mL NO_2)
- Glass syringe with small amount of vacuum grease applied to the plunger

Or **NEW** 60 mL plastic disposable syringes with a Luer lock tip. Lubricate the plunger with a small amount of vacuum grease or sewing machine oil to improve their 'gastightness' under pressure.

- Luer lock caps
- Glass Pasteur or 2–3mL graduated pipette
- 3 large test tubes plus stoppers
- Ice water bath
- Warm water bath (60–70^{o}C)

Note: Hoffman tubing clamps are not required for the tubing, as they will create an additional hazard.

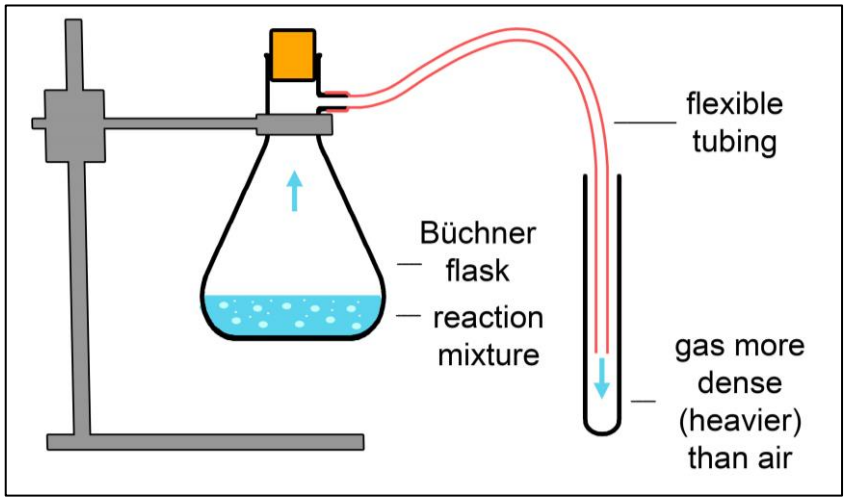
Collection in test tubes

Procedure (See Figures 1a,b):

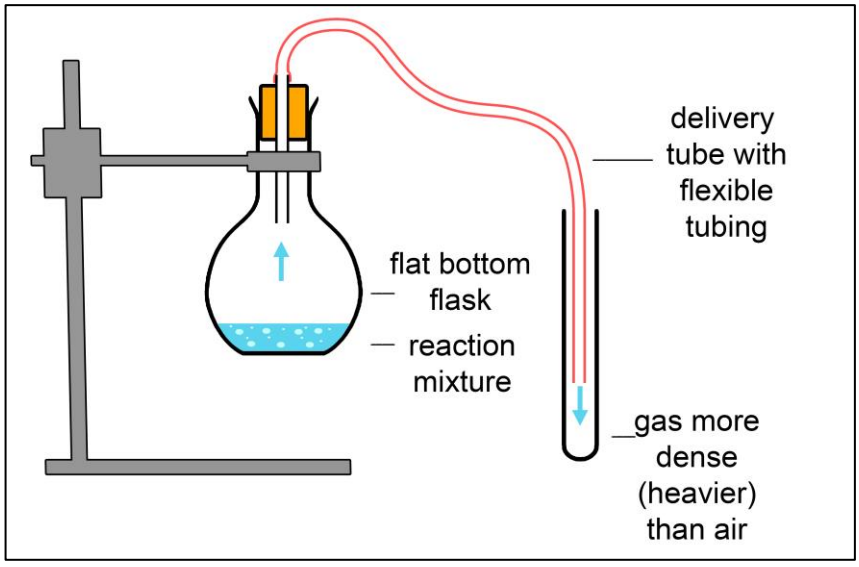
1. Attach the flexible tubing to the side arm of the Büchner flask or delivery tube and set up the equipment in the fume cupboard with the flask clamped securely to a retort stand so that it doesn't tip over.
2. Have the test tubes ready to be filled via the length of tubing. Have the stoppers nearby.
3. Place the copper foil/turnings into the flask; add the nitric acid and then stopper the Büchner flask with the solid stopper (or round bottom/flat bottom flask with the delivery tube stopper assembly).
4. As the gas is produced, collect it in each test tube by downward delivery (the more dense nitrogen dioxide gas will sink down into the test tube resulting in the upward displacement of the less dense air).[6]
5. When the test tubes are filled with gas, insert the stopper.
6. The test tubes should then be put into three different temperatures and any colour changes observed, as in the above demonstration to observe the effect of temperature.
7. When sufficient gas has been collected, water should be added to the reaction vessel to quench the reaction.
8. After the test tubes have been observed for any colour change, return the test tubes to the fume cupboard, then unstopper the test tubes and either allow the gas to dissipate or immerse the test tubes in water.

Figures 1a, b: Gas collection system for preparing and collecting a gas in a test tube. The NO_2 gas which is more dense than air sinks down into the test tube, and displaces, the less dense air upwards. This is called downward delivery of gas.

1a) Using a Büchner flask



1b) Using a flat bottom or round bottom flask



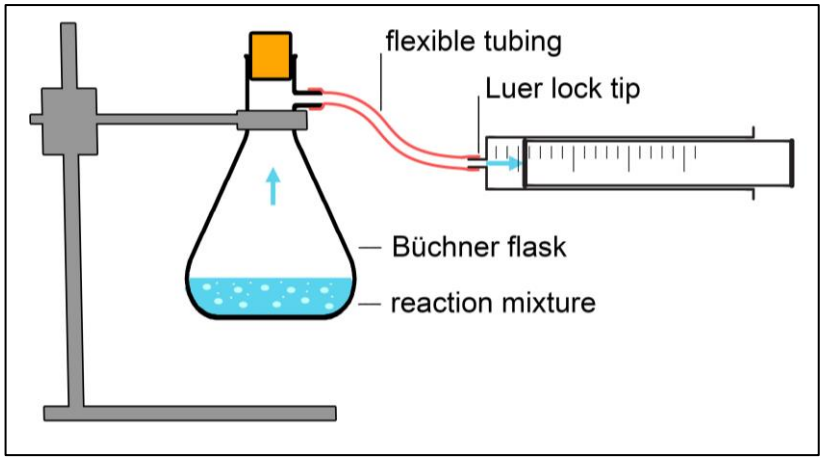
Collection in syringes

Procedure (see Figures 2a, b**):**

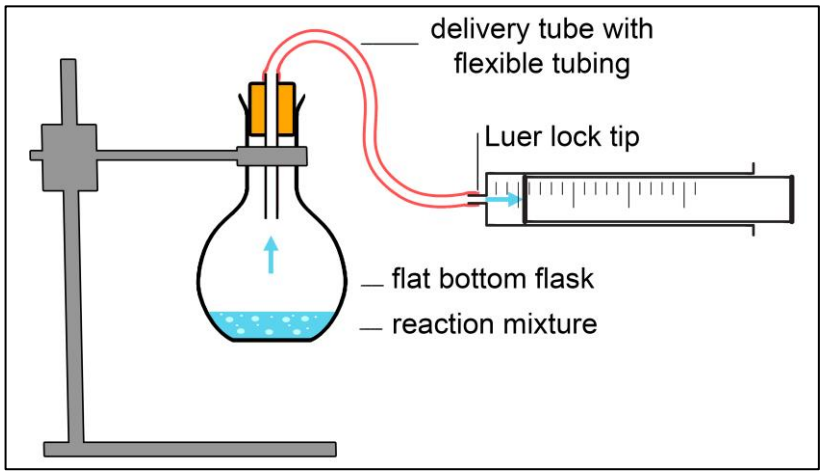
1. Attach the flexible tubing to the side arm of the Büchner flask or delivery tube and set up the equipment in the fume cupboard with the flask clamped securely to a retort stand so that it doesn't tip over.
2. Have the syringes ready to be filled via the length of tubing. The plunger must be depressed all the way in and the Luer lock cap available nearby.[7]
3. Place the copper foil/turnings into the flask, add the nitric acid and then stopper the Büchner flask with the solid stopper (or round or flat bottom flask with the delivery tube stopper assembly).
4. As the gas is produced, connect the flexible tubing to each syringe in turn. Observe the syringe being filled with brown gas and the movement of the plunger. When filled to a sufficient level, remove the tubing and close the tip of the syringe using the Luer lock cap.
5. Take care to stop the gas collection before the end of the graduations is reached, to avoid the plunger being forced from the syringe
6. When sufficient gas has been collected, water should be added to the reaction vessel to quench the reaction.

Figures 2a, b: Gas collection system for preparing and collecting a gas in a syringe.

2a) Using a Büchner flask



2b) Using a flat bottom or round bottom flask



When the syringes have been sealed to prevent the loss of gas, they can be taken out of the fume cupboard into a well-ventilated room and the effect of pressure on the equilibrium demonstrated as below:

Rapidly depress the plunger of the syringe as far as it can go. The colour should become darker initially as the gas concentration increases due to a decrease in volume. It then becomes paler in colour as the equilibrium adjusts, converting the brown nitrogen dioxide to colourless dinitrogen tetroxide.

When the plunger is pulled back decreasing the pressure the colour changes in reverse to above.

Once they are finished with, the syringes should not be opened and the gas should not be released into the classroom but returned to the fume cupboard. Here the syringes can have their stopper or cap removed to allow the gas to dissipate, or can simply be rinsed with water.

The prepared gases should last as long as they are contained in the syringes without leaks. Nitrogen dioxide weakens rubber, so this does not provide a long-term seal. Ideally, they should be made up as close as possible to the time required and disposed of as soon as practicable when finished.

Alternative methods

In-Syringe Method for microscale gas using solid sodium nitrite and acidified iron sulfate solution

The In-Syringe Method is described in detail by Bruce Mattson and Michael P. Anderson and 'features the generation of gases by reacting two chemicals, typically one solid and one aqueous liquid, inside a plastic syringe.'[8] Prior to manufacturing toxic NO_2 gas, it is recommended that users practice (and are competent in using) the in-syringe method with gases such as CO_2, H_2 and O_2.[9]

The heating and decomposition of lead nitrate[5]

This method has different hazards and results in the production of heavy metal waste. Therefore, this is not the preferred method of production of NO_2 gas.

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ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

LABORATORY NOTES:

Phenolphthalein/NaOH agar cube experiment to model the effect of surface area to volume ratio on rate of diffusion in cells

The impact of cell size on diffusion can be modelled with a simple experiment using different size cubes of agar containing a pH indicator. The agar cubes represent biological cells. The volume of the cube correlates to the cytoplasm and the surface area of each cube to the cell membrane.

All living cells are dependent on diffusion processes for survival. These processes transport materials across the cell membrane into and out of the cell. As the volume of the cell increases, the surface area per unit volume decreases. Knowledge of the relationship between the size (volume) of cells and their surface area helps explain the process of diffusion.

Agar blocks and cells with the largest surface area to volume ratio (the smaller cubes) have the highest diffusion rates.

The following method gives reliable results.

Phenolphthalein – sodium hydroxide agar

Materials

- Plain agar powder 20g
- Distilled/deionised water 900mL
- Phenolphthalein indicator 2.0% w/v solution in 60% ethanol (See instructions below)
- 100mL of 1M Sodium hydroxide solution (4g NaOH dissolved in 100mL distilled/deionised water)
- Magnetic stirring/heating platform and magnetic stirring bar
- Straight-sided tray for setting gel. Suitable trays are the ‘Dabco Unitrays’, preferably without the divider, or other suitably sized trays such as ice cube trays.
- 1mL pipette

For student use

- Plastic spoon
- 250mL beakers
- Scalpel/flat blade knife
- Diffusing solution: 0.1M hydrochloric acid or 0.1M sulfuric acid
- Timer
- Clear plastic ruler that measures in mm
- Disposable nitrile gloves
- Paper towel

Method:

- Add 20g of plain agar powder slowly to 880/890mL of distilled/deionised water whilst stirring constantly. (This is best done by stirring the water using a magnetic stirring bar on a magnetic heater/stirrer and slowly adding the agar to the water. Bring to the boil, and then simmer for a few minutes until completely dissolved. Remove off the heating platform and place on a heatproof mat. N.B keep covered with foil to prevent a skin forming.)
- When the agar has cooled to approximately 60°C add 100mL of 1M sodium hydroxide solution, stirring constantly (stir using the magnetic heater/stirrer again without the heat). The final concentration of sodium hydroxide is 0.1M. **Make sure that you wait until the agar has cooled to just below 60°C (and well prior to setting which is about 40°C) before adding the sodium hydroxide solution.**
- Add 10-20mL of 2.0 % Phenolphthalein indicator quickly whilst stirring constantly, **until the agar is a deep pink colour.** Note it may be necessary to add more Phenolphthalein indicator depending on the intensity of colour required. Be aware, however, that the ethanol may affect the firmness of the agar.
- Pour into a shallow tray to a depth of >30 mm and allow to set.
- Cut the agar into 1, 2 and 3cm cubes using a scalpel blade and/or flat blade knife. 1 cube of each per group.
- Add cubes to a beaker containing enough diffusing solution of either 0.1M hydrochloric or 0.1M sulfuric acid to completely cover all the agar cubes.
- Periodically turn the cubes over and stir with the plastic spoon while timing how long it takes for the different size blocks to decolourise. The change from pink to colourless indicates the extent to which the acid (hydrogen ions) has diffused into the agar cubes.
- Determine the surface to volume ratio for each cube and relate to the time taken for each block to decolourise.
- Alternatively: when the first agar block clears completely remove all the blocks from the acid with the spoon, rinse the agar blocks quickly with water and pat dry with paper towel. Working quickly cut the blocks in half and measure the depth of the clear layer in millimetres in each block. This is the depth that the acid has penetrated each block.
- Determine the surface to volume ratio for each cube and relate to the time taken for each block to partially decolourise.

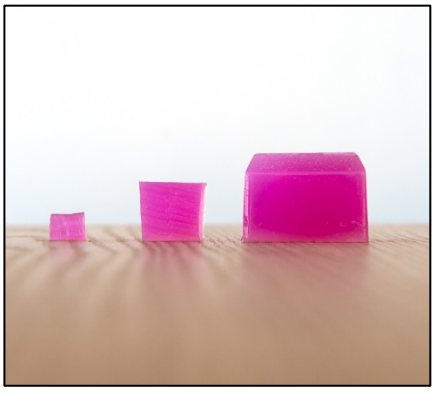

Image attribution: Exploratorium Teacher Institute

Additional tips:

- Increasing the amount of agar from 20g/L to 25g/L achieves a firmer gel.
- When completely cool, agar can be covered with cling wrap and stored in the fridge for several days before use.

Safety considerations:

- Consult safety data sheets for all chemicals used.
- Wear appropriate Personal Protective Equipment (PPE) – safety glasses and nitrile disposable gloves.
- Agar that contains sodium hydroxide is alkaline and has a soapy feel. Wear disposable gloves when handling.
- Sodium hydroxide and acid solutions are corrosive. Wear safety glasses to protect the eyes and disposable gloves to protect the skin.
- Phenolphthalein solution is a flammable liquid and should be kept away from heat and sources of ignition preferably in a flammable liquids cabinet.
- Phenolphthalein indicator can be prepared in house taking into account the safety considerations below. Alternatively, it can be purchased ready made from various scientific suppliers.

Waste disposal

Rinse the agar cubes with water to dilute and remove residual acid or alkali and dispose of into the rubbish bin.

Neutralise the acid diffusion solution, using a base such as sodium carbonate, and dispose of to waste water.

Preparation of phenolphthalein indicator

- When preparing indicators, such as phenolphthalein, it is essential to observe safe handling practices to minimise exposure to any dust.
    - Wear PPE: safety glasses, gloves, laboratory coat and closed in shoes. Wear a dust mask, or work in a fume cupboard that is not turned on, with the sash lowered, to minimise exposure to any dust. Position an electronic balance in the fume cupboard. If working outside a fume cupboard, make sure you work in a draft free area.
    - Carry out any transfers of the powder in a shallow tray in the fume cupboard. The tray will contain any spills of the powder.
    - After the solution has been prepared, switch the fume cupboard on. With damp paper towel, wipe down any surfaces which may be contaminated with the powder
- When preparing the phenolphthalein indicator, it is best to dissolve the solid phenolphthalein in the ethanol first due to its low solubility in water and then make up to the required volume.
- For this activity a solution of 2% phenolphthalein in 60% ethanol is recommended to enable a deep pink colour. i.e. 2g phenolphthalein dissolved in 60mL of ethanol and then made up to 100mL with distilled water.
- This stock solution could be further diluted to produce a general-purpose indicator of 0.1% phenolphthalein in 60% ethanol, by taking 5mL and diluting up to 100mL with 60% ethanol. [or 5mL of 2% phenolphthalein in 60% ethanol + 57 ml ethanol and 38 mL distilled water]

Alternative methods:

There are variations in the literature for cell diffusion experiments, however Science ASSIST has not trialled them. Here we provide links from two reputable sources for those who wish to trial a different method.

- 'Effect of size on uptake by diffusion', Nuffield Foundation website, http://www.nuffieldfoundation.org/print/3128 (Accessed November 2018)

  (**Note**: *This method uses universal indicator in place of phenolphthalein*)

- Flinn Scientific. 2018. *Diffusion in Agar Cells*. Flinn Scientific website, https://www.flinnsci.com/api/library/Download/7ab4bee9010448c4a2732ef34c570c6b

  (**Note**: *This method uses sodium hydroxide as the diffusing solution)*

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ASSIST AUSTRALIAN SCHOOL SCIENCE INFORMATION SUPPORT FOR TEACHERS AND TECHNICIANS

LABORATORY NOTES:

Preparing chemical solutions

A solution is a homogeneous mixture of one or more solute(s) dissolved in a solvent. A solute is a substance that is dissolved in a liquid solvent to produce a solution.

There are a wide range of chemicals used in solution form for various experimental activities and demonstrations in the school science curriculum. These solutions are required in different strengths or concentrations based on intended activity.

The concentration of a solution refers to the quantity of solute dissolved in a particular quantity of solvent or solution. There are several ways of expressing solution concentrations such as moles per litre, percentage concentration, grams per litre, saturated solutions etc.

In a school science laboratory there are 5 main methods used for the calculation of and preparation of solutions.

1. Concentration in moles per litre, molar concentration or molarity (mol/L or mol L^{-1} or M)
2. Concentration by percentage (either %w/v or % v/v or sometimes %w/w)
3. Concentration in grams per litre (g/L or g L^{-1})
4. Preparing solutions by dilution
5. Preparing saturated solutions

1. Concentration in moles per litre, molar concentration or molarity

The mole

The mole is a unit of measurement used to describe the amount of a chemical species. It can be used to describe the number of atoms, molecules, ions, electrons, etc. The abbreviation of mole or moles is *mol*.

One mole contains 6.022×10^{23} particles (atoms, molecules, ions, electrons). This is known as Avogadro's number.

The use of the term *mole* in chemistry is analogous to how the word *dozen* is used in everyday language. For example, one dozen apples is 12 apples, while one mole of apples would be 6.022 x 10^{23} apples.

The weight in grams of one mole of a substance is the molecular weight (MW), or molar mass, of that substance. To determine the number of moles, n, in a given quantity of a substance, you divide the given quantity of the substance by the molecular weight:

$$n = \frac{mass\ of\ substance\ (g)}{molecular\ weight\ (g)mol} = \frac{m}{MW}$$

Molarity

In chemistry, molarity is the most frequently used method of expressing concentration of a solution. **Molarity** indicates the number of moles of solute dissolved in a litre of a solution; has the symbol M, and the unit, *moles per litre (mol/L).*

The concentration of a solution in mol/L can be calculated using the formula

$$c = \frac{n}{v} \ (moles\ per\ litre)$$

$$concentration = c = \frac{number\ of\ moles\ of\ solute\ (mol)}{volume\ (L)}$$

Where *c* = concentration of the solution in moles per litre (mol/L)

n = amount of moles of solute (mol)

V = volume of solution in litres (L)

The equation $c = \frac{n}{V}$ can be rearranged to find the number of moles of solute in a certain volume of a solution of known concentration

$$n = c\ x\ V$$

To find the volume of a solution of known concentration which will give you a certain number of moles of the solute

$$V = n/c$$

A molar solution

The symbol M is pronounced 'molar'. Molar solutions use the molecular weight of a solute to calculate molar concentration in a litre of solution.

The molecular weight can be found on the chemical bottle label, in a data book or safety data sheet (SDS), or by adding together the atomic weights of all of the atoms, which appear in the chemical formula of the substance.

e.g. NaCl

1 sodium atom 1 x 22.9 g = 22.99 g

1 chloride atom 1 x 35.45 g = 35.45 g

Molecular weight = 58.44 g

Therefore, a 1M solution of sodium chloride consists of 58.44 g of NaCl dissolved in 1 L of water.

Note: If you are using a hydrated salt, the water(s) of hydration must be included in the calculation of the molecular weight.

Once the molecular weight of a chemical is known the following formula is used to calculate the weight of chemical to dissolve in solution for varying molar solutions.

Combining 2 equations $c = \frac{n}{V}$ and $n = \frac{m}{MW}$ the following formula is obtained

$$m = c\ x\ V\ x\ MW$$

Where:

m = mass of solute in grams (g)

c = concentration of solution in moles per litre) (mol/L)

V = volume of solution in litres (L)

MW = molecular weight of solute in grams (g)

'1M' is pronounced 'one molar' and contains the molecular weight of a chemical dissolved in one litre of water. A '2M solution' is pronounced 'a two molar solution' and has twice the molecular weight of a chemical dissolved in one litre of water.

Example 1: Calculation for preparing 1 litre of a 0.5 M copper (II) sulfate solution

Note that we are using copper (II) sulfate **pentahydrate**, ($CuSO_4.5H_2O$)

$Molecular\ weight = MW = 63.55 + 32.06 + (4x15.99) + \mathbf{5}((\mathbf{2x1.008}) + \mathbf{15.99})) = 249.68\ g$
$Concentration = c = 0.5\ M$
$Volume = V = 1\ L$

The quantity of the solid copper sulfate pentahydrate required to make 1L of 0.5M solution

$$\begin{aligned} m &= c\ x\ V\ x\ MW \\ &= 0.5\ x\ 1\ x\ 249.68 \\ &= 124.84\ g \end{aligned}$$

Examples 2 and 3 below compares the use of anhydrous, meaning no water, and monohydrate, meaning having one water of crystallisation, solids of the same compound for preparation of 250 mL of 0.2 M solutions. Note the difference in molecular weights.

Example 2: Calculation for preparing 250 mL of a 0.2 M solution of sodium carbonate using the anhydrous salt (Na_2CO_3).

Before performing the calculation, we convert the volume, 250 mL, to litres, i.e. 0.25 L.

$Molecular\ weight = MW = 105.99\ g$
$Concentration = c = 0.2\ M$
$Volume = V = 0.25$ L

The quantity of the solid sodium carbonate required to make 250 ml solution of 0.2 M solution

$$\begin{aligned} m &= c\ x\ V\ x\ MW \\ &= 0.2\ x\ 0.25\ x\ 105.99 \\ &= 5.30\ g \end{aligned}$$

Example 3: Calculation for preparing 250 mL of a 0.2 M solution of sodium carbonate using sodium carbonate monohydrate (Na2CO3.H2O).

$Molecular\ weight = MW = 124.00\ g$
$Concentration = c = 0.2\ M$
$Volume = V = 0.25\ L$

The quantity of the solid sodium carbonate monohydrate required to make 250 mL solution of 0.2M

$$m = c\ x\ V\ x\ MW$$
$$= 0.2\ x\ 0.25\ x\ 124.00$$
$$= 6.20\ g$$

Method to prepare a solution using a solid chemical in

1 L of distilled or deionised water

1. Calculate the amount of chemical required to make 1 L of solution at the required molarity.
2. Weigh the amount of chemical using an electronic balance onto a clean, dry watch glass or weighing boat.
3. Carefully transfer the weighed chemical to a beaker containing about two thirds of the final solution volume of distilled or deionised water (about 500-650 mL). When preparing solutions, the solute is dissolved in a portion of the total volume required and then the volume is made up to the required volume.
4. Using a wash bottle containing either distilled or deionised water, wash the watch glass or weighing boat into the beaker to remove all traces of weighed chemical.
5. Stir to dissolve with a stirring rod or on a magnetic stirring platform.
6. It may be necessary to gently heat the solution to speed up the dissolution of the salt.
7. Once dissolved transfer the solution to a 1 L measuring cylinder or volumetric flask.
8. Rinse the beaker, stirring rod and filter funnel using a wash bottle and transfer the washings to the measuring cylinder or volumetric flask.
9. Make up to 1 L with distilled or deionised water. Make sure that the vessel and solution is at room temperature and that the bottom of the meniscus is in line with the mark on the neck of the volumetric flask or the 1 L mark on the measuring cylinder.
10. Stopper and mix thoroughly.
11. Transfer the solution to a labelled reagent bottle.

Note: If preparing a solution directly using a volumetric flask the final volume should be measured with the solution and vessel at room temperature, as this is the temperature at which volumetric glassware is calibrated. If heating the solution, a beaker or conical flask should be used rather than a volumetric flask, as heating volumetric glassware may affect its calibration.

2. Concentration by percentage

The concentration of a solution can be expressed as a percentage concentration, usually as %w/v or %v/v and also sometimes as %w/w.

Where the solute is a solid:

Percentage weight per volume (%w/v) is used. This is the mass of solute (solid) in grams dissolved in 100 ml of solution.

$$\%w/v = \frac{(mass\ of\ solute\ (g)}{volume\ of\ solution\ (mL)} x\ 100\%$$

Alternatively,

%w/v = mass of solute (g) in 100 mL of solution.

Example: a 2%w/v solution of sodium chloride would be prepared from 2 g of sodium chloride dissolved in water and made up to a volume of 100 mL.

Where the solute is a liquid:

Percentage volume per volume (%v/v) is used. This is the volume of solute (liquid) in millilitres per 100 mL of solution.

$$\%\ v/v = \frac{(volume\ of\ solute)}{volume\ of\ solution} x\ 100\%$$

Alternatively,

%v/v = volume of solute (mL) in 100 mL of solution.

Example: a 5%v/v aqueous solution of ethanol would be prepared by taking 5 mL of pure ethanol and diluting this with water to a volume of 100 mL.

Weight percent (%w/w):

This is the mass of solute in grams per 100 g of solution. It is often used in aqueous commercial preparations, for example in concentrated solutions of acids. A weight percent concentration has the advantage that the solution can be prepared independently of temperature considerations. Generally not used in school science.

$$\%w/w\ = \frac{(mass\ of\ solute)}{(mass\ of\ solution)}\ \ x\ 100\%$$

Alternatively,

%w/w = mass of solute (g) in 100 g of solution

3. Concentration in grams per litre

A solution can be prepared by dissolving a known mass or volume of solute in a known amount of solvent.

Concentration is expressed as grams of solute dissolved in one litre of solution.

Example: Calculation for preparing 300 mL of a sucrose solution at a concentration of 5 g/L.

As only 300 mL (0.3 L) of solution is required, only a fraction of the 5 g will be needed.

To find the quantity of sucrose required, the concentration is multiplied by the fraction of litres required:

$$m = 5\ g/L\ x\ 0.3\ L$$

$$m = 1.5g$$

This amount of sucrose is weighed out and dissolved in enough water to make up the volume to a total of 300 mL.

4. Preparing solutions by dilution

Dilution is the process of adding more solvent to a solution.

Solutions can be prepared by diluting a solution of a known higher concentration to produce solutions of lower concentration

Often a stock solution is a concentrated solution that is diluted to a lower concentration for use, called a working solution.

When carrying out a dilution, a definite volume of the concentrated solution is measured out and placed in a volumetric flask of required volume and sufficient solvent is then added to make up to the calibration mark.

It is useful to remember that the dilution does not alter the number of moles of solute present. Only the volume of the final solution changed due to addition of extra solvent. Calculation of the required volume of the initial concentrated solution to produce the diluted solution is based on this fact that the number of moles of solute is the same before and after the dilution.

From the equation $c = \frac{n}{V}$, $n = c\ V$ is obtained.

Where, *n* = amount of moles of solute (mol)

c = concentration of solution in moles per litre (mol/L)

V = volume of solution in litres (L)

Since number of moles of solute is not changed, volume of concentrated solution can be calculated as below.

$$n1(number\ of\ moles\ before\ dilution) = n2(number\ of\ moles\ after\ dilution)$$

$$c1V1 = c2V2$$

$$V1 = \frac{c2\ V2}{c1}$$

Where:

V1 = initial volume or the volume of concentrated solution (in litres)

c1 = concentration of the initial solution or concentrated solution

V2 = final volume or the volume of diluted solution (in litres)

c2 = concentration of the final or diluted solution

Example 1: Preparation of 500 mL of 0.5 M Hydrochloric acid (HCl) from a 2 M solution of HCl.

$$Cl)before\ dilution = n2\ (HCL)after\ dilution$$

$$c1V1 = c2V2$$

$$2\ x\ V1 = 0.5\ x\ .5$$

$$V1 = \frac{0.5\ x\ .5L}{2}$$

$$V1 = 0.125\ or\ 125mL$$

This volume of 2 M HCl is measured and placed in a 500 mL volumetric flask containing about 250 mL distilled water. Then enough distilled water is added to make up to the 500 mL mark. The solution should be mixed well to obtain a homogeneous solution of 0.5 M HCl.

Example 2: Diluting hydrogen peroxide (H_2O_2) solution

The strength of hydrogen peroxide is often expressed in volumes. This relates to the volume of hydrogen peroxide and the number of volumes of oxygen gas it can produce upon decomposition.

Hydrogen peroxide (H_2O_2) decomposes to water and oxygen.

$$2H_2O_2 \qquad 2H_2O + O_2$$

1 volume (1 mL) of 20-volume hydrogen peroxide will produce 20 volumes (20 mL) of oxygen as a gas.

For example, taking 10 mL of 20 volume hydrogen peroxide, decomposition of the hydrogen peroxide will produce 20 x 10 mL = 200 mL of oxygen gas.

Both 100 volume (30% solution) and 120 volume (35% solution) concentrations are commercially available to purchase. 20 volume (6%) concentration is the common strength of hydrogen peroxide used for science investigations in schools.

Calculation for the preparation of 1L of a 20 volume (6%) solution of hydrogen peroxide from 100 volume (30%) solution. 100 volume is the initial concentration and 20 volume is the final concentration.

$$1 = c2V2$$

$$V1 = \frac{c2V2}{c1}$$

$$V1 = \frac{20\ x\ 1}{100}$$

$$V1 = 0.2L\ or\ 200\ mL$$

200 mL of 100 volume hydrogen peroxide is added to approximately 500 mL of distilled water and made up to 1L. The diluted solution should be mixed well.

Alternatively, the calculation using percentage concentrations also can be used. 30% is the initial concentration and 6% is the final concentration.

$$c2V2$$

$$V1 = \frac{c2V2}{c1}$$

$$V1 = \frac{6\%\ x\ 1}{30\%}$$

$$V1 = 0.2L\ or\ 200\ mL$$

5. Saturated solutions

The solubility of a solute is the maximum amount that can dissolve at a specified temperature in a specified volume of a particular solvent. Solubility depends on type of solute, type of solvent and temperature.

A saturated solution is where at a particular temperature no more solute can be dissolved in the solvent. This is where despite stirring no more of the solute can be dissolved and the excess settles in the bottom of the beaker.

The solubility of most solids increases with increasing temperature, so a saturated solution prepared at a high temperature will contain more dissolved solute than it would contain at a lower temperature. If a saturated solution prepared at a high temperature is cooled then the solute will come out of solution relative to the temperature to which it cools.

Before preparing a saturated solution of a chemical it is necessary to determine its solubility in a given amount of solute at a particular temperature.

The solubility of most chemicals (how much will dissolve in a solvent at a given temperature) can be obtained from a chemical data book, the safety data sheet or from a solubility curve of the chemical.

A solubility curve compares the amount of solute that will dissolve in a given amount of solvent at various temperatures. Generally the solvent is water and the concentration is provided in grams of solute in 100 g of solvent. Solubility curves are different for different chemicals.

Example: A saturated solution of sucrose

The solubility of sucrose at 20^0C is 203.9 g / 100 mL of water. The solubility of sucrose at 100^0C is around 500 g / 100 mL of water.

If you try to dissolve 220 g of sucrose in 100 mL of water at 20^0C then 203.9 g will dissolve forming a saturated solution and the remaining 16.1 g will settle to the bottom of the beaker. The undissolved solute can be separated from the saturated solution by filtration.

References and further reading

Dungey, Barbara. 2003. *The laboratory – A Science reference and preparation manual for schools*. Rev. ed. R O & B Dungey: Traralgon, Victoria

'Laboratory solution preparation', Flinn Scientific website, https://www.flinnsci.com/laboratory-solution-preparation/dcat016/ (Accessed November 2018)