ASSOCIATION FOR SCIENCE EDUCATION

Working with GLASS

School and College Laboratory Technicians' Guide

Introduction

It has long been an aim of the ASE Technicians' Committee to provide colleagues with some help within the area of training.

Hands-on courses are the ideal training for a practical subject; however, the results of a 2024 survey by Preproom.org* suggests that only 30% of technicians are encouraged to attend CPD regularly and up to 20% of technicians struggle to access any professional learning. Nearly 47% of technicians feel that they do not receive enough training.

This series of *Technicians' Guides* aims to go some way to redressing the balance and compensating for the difficulties encountered in attending face-to-face CPD.

* 2024 UK School & College Technician Survey, https://www.preproom.org/downloads/2024-UK-School-and-College-Technician-Survey.pdf

Each *Technicians' Guide* covers one topic and provides background information, details of useful procedures and health and safety advice, to support the excellent service offered by technicians to school and college science.

The contents will be particularly useful for new technicians, for those more experienced technicians guiding them and for those working towards qualifications such as S/NVQ. The design of the Guides, with each topic being made available singly, will allow technicians to build up their own handbook of operating procedures, adding in new titles as they are published.

Working with glass

Working with glass is an extremely important task for the school or college technician. Not only does the technician need to be aware of the personal risks from hot and sharp materials, but also of the risks to teachers and students who will handle the equipment. The technician has a duty of care to provide safe equipment for teachers and pupils to use. *Working with Glass* provides information for the technician on preparing simple glass objects and threading glass tubing and thermometers through rubber bungs. It will be particularly useful for the new technician and for anyone who is working towards qualifications. It will also help experienced technicians from other disciplines to widen their skills.

ASE Technicians' Committee (2024)

We'd like to thank members of the Technicians' Committee and the ASE Health and Safety Committee for their help in putting this guidance together.

ASE is grateful to the Worshipful Company of Glass Sellers Charity Fund, whose funding has made this resource and accompanying films possible. The Worshipful Company of Glass Sellers has had no input into the content or delivery of the resources or films.

ASSOCIATION FOR SCIENCE EDUCATION

Contents

Working with Glass

1. Introduction

Glass is the workhorse material of practical science in schools and colleges. It is often subjected to extreme abuse, both mechanical and chemical, and extreme heat. Students should not be using glass that is cracked, chipped or has sharp edges. Nor should they use glass that is known to shatter when subjected to the thermal shock of being placed in a Bunsen flame.

All glassware intended to be heated in an autoclave, on a hot plate or in a Bunsen flame should be made of borosilicate glass. This rule should apply to beakers, conical flasks and tubing to be made into delivery tubes (6 or 7 mm medium-wall borosilicate).

The ASE Laboratory Technicians' Committee would like to acknowledge the work and guidance of CLEAPSS and SSERC that has been referred to when producing this guide.

2. What is glass?

2.1 The composition and properties of glass

There are three types of glass on sale for technicians to work with: soda, neutral borosilicate and borosilicate. The properties of these three types of glass are listed in Table 1.

Table 1 ***Typical properties of various glasses***

	Soda	Neutral borosilicate	Borosilicate
Typical chemical composition	SiO_2 73% B_2O_3 0.8% Na_2O 15.2% Al_2O_3 1.7% CaO 4.6% MgO 3.6%	SiO_2 73% B_2O_3 10% Na_2O 2% Al_2O_3 7% K_2O 2%	SiO_2 80.6% B_2O_3 13.0% Na_2O 4.0% Al_2O_3 2.3%
Softening point (°C)	730	785	827
Expansion coefficient [(x 10-6) K1]	8.9	5.5	3.3
Density (g cm-3)	2.50	2.33	2.23
Refractive index	1.52	1.49	1.47

Borosilicate glass has a similar refractive index to propane-1,2,3-triol. When apparatus made of this glass is placed in this liquid, it appears to disappear from view. Borosilicate glass does not soften as readily as the other types of glass.

2.2 Structure of glass

Glass is a supercooled liquid. The internal structure consists of a random array of ions. In time (years!), these ions slowly move and arrange themselves in a crystalline pattern, which makes the glass fragile so that it shatters more readily when either heated or moved. This process is called devitrification. The shelf-life of soda glass tubing could be as little as 6 months due to devitrification.

3. Logistics

3.1 Buying

Glass for laboratory use should be of a reliable quality. Pyrex is a particular brand of borosilicate glass made by Corning. Kimble/Kontes KG-33, Samco 33 are also types of borosilicate glass and should be made to the same standard as Pyrex. However, all manufacturers should insist on good quality control and, if you receive a supply of borosilicate glass that regularly 'explodes' during use, it should be returned to the supplier. All borosilicate glass items are labelled individually, usually in white script. This labelling does not apply to neutral borosilicate or soda glass. Take care with glass from general education suppliers. They may use the word 'borosilicate' to describe the neutral borosilicate glass.

ASE recommends that any glassware (e.g. test tubes or beakers) that comes into contact with a Bunsen flame should be made of borosilicate glass, not neutral borosilicate or soda glass.

The size of glass tubing is given in terms of the outside diameter and wall thickness. So that you will obtain smooth bends during any glass work, it is recommended that 6 or 7 mm medium-wall borosilicate tubing is used.

3.2 Storing and transporting

Rod and tubing should be stored horizontally, in a position where it cannot roll off (one suitable means of storage is in plastic guttering). It should be labelled according to size, type and date of supply. The oldest glass can be used first, unless it is devitrified (i.e. crystalline) soda glass, which may need to be disposed of. Expensive and smaller glass items should be placed in trays in secure drawers or cupboards. Every effort should be made to avoid vibrating the glass as drawers are pulled out. To avoid this, line the drawers with expanded plastics and lubricate the runners of the drawers. Do not store dirty glass!

Glass tubing and rods should be carried by hand in a vertical position. Transporting glass on trolleys (especially over rough ground) will subject it to severe mechanical shock unless precautions are taken.

3.3 Cleaning

Glass apparatus should always be cleaned as quickly as possible after use, especially if alkalis have been used. The wearing of gloves is recommended for protection. The use of chromic acid (which is both toxic and corrosive) should be avoided. The apparatus should be rinsed in water and left in a proprietary cleaning agent if necessary, according to instructions. Hard water deposits on glass are removed by rinsing the equipment in 0.1 mol dm-3 hydrochloric acid. Any solid chemical deposits can be removed with a suitable nylon brush, and the glass then rinsed with tap water and finally pure water. The glass can be dried by leaving it to drain overnight or placing in a drier.

If a domestic dishwasher is used, the glassware ought to be rinsed again with distilled water before it is put away, as the glass will contain deposits from tap water. If a drier is available, this would not be too time-consuming to use.

3.4 Disposing

Broken glass should not be placed in the general waste bin, as it could injure those emptying the bin. There should be a specially labelled waste bin for glassware, which is emptied regularly. The glass should be collected from the special bin, wrapped in newspaper or put into a cardboard box, and then placed into the normal dustbin/waste container.

3.5 Control measures

Even the most experienced technicians can suffer cuts and burns when working with glass. Please make sure that a colleague is within calling distance and that you are not likely to be interrupted during the work.

3.6 Immediate remedial measures

Cuts: Run cold water over the cut. Call a colleague to seek first aid.
Burns: Run cold water over the burn area for 5 to 10 minutes. Call a colleague to seek first aid.

4. Some basic procedures

This section contains some basic safe procedures for working with glass.

In time, you will develop your own procedures depending on your experience and working environment, so an extra page has been included for you to photocopy and fill in, or to use as a model on your own computer. Rewriting procedures is tedious, but minor alterations are easy to do if the procedures are on a computer.

Why do we need procedures?

- **So you don't forget**

Accidents often happen due to over-familiarity with certain procedures.

- **Procedures record your risk assessments**

Any significant findings of risk assessments need to be recorded. A model risk assessment, from the employer, should set your mind working, but local conditions can add further conditions that you and your line manager should agree to. The control measures that you adopt should be added in the text.

- **Procedures help with learning new techniques**

Courses organised by your employer, local self-help groups and INSET organised by your school will introduce you to new techniques. If these are unfamiliar, it is best to tackle them slowly and record the method and improvements.

- **Procedures help the new technician**

You can pass on all your ideas and improvements and so can save time.

- **Procedures provide evidence of what you do and how you do it**

You may need to demonstrate your expertise to certain people who are unclear about what a technician does. Non-science teachers often question why science appears so special in having such help.

4.1 Cutting and flame-polishing glass rod and tubing

Hazards	Sharpness of glass. Very hot glass.
Control measures	Wear eye protection. Gloves can be worn, but the wearing of gloves may interfere with any delicate procedure. Hold lengths of glass vertically when carrying them to the place of work. Make sure that you know how to deal with any cuts or burns.
Equipment required	Medium-wall borosilicate glass tubing or rod of the required diameter, glass cutter or tube cutter or file, wire gauze, Bunsen burner, bench (heat-proof) mat, matches.
Procedure	• Place the glass on the bench mat. • Measure the length of glass that you require. • With one bold stroke (if possible) of the glass cutter or file, make a mark. You should be able to see the mark and hear the grinding of glass. • Keep looking at the mark and place a little water (or soapy water) on the mark. • Turn the glass slightly so that the mark is pointing away from your body. Snap the two pieces of glass apart while at the same time exerting slight pressure behind the scratch with your thumbs. • Examine the glass to see if there are any sharp points. If there are, rub them with a wire gauze. • Place the end of the glass at the top of the roaring Bunsen flame and lower it so that it is just above the blue cone. Rotate and keep it there until the end of the glass just melts. This is called **flame-polishing.** • Turn the tubing or rod round and flame-polish the other end. • Leave the glass on the bench mat to cool.

Additional information

You should supply glass rod and tubing in a safe condition to be used by others, so flame-polishing is an essential process.

There is no need to mark right around the glass.

Wetting the glass is said to give a smoother break.

The rod or tubing should be less than 8 mm outside diameter, the larger the diameter the more difficult it is to cut.

If time allows, the cooling of glass should be as slow as possible. This process, called **annealing**, produces fewer strains on the glassware and makes it 'tougher'. Leave the glass in the flame but turn the air-hole on the Bunsen to half-open for five minutes. Finally close the air-hole altogether. The carbon coats the glass and the glass can be removed to cool to room temperature.

Do not be tempted to rush any procedure.

Procedure time Insert the time taken to carry out this procedure.

Further comments
Please use the below space to make any additional comments you have on the procedure

4.2 Making a teat pipette

Hazards Sharpness of glass. Very hot glass tubing. .

Control measures Wear eye protection. Gloves can be worn, but the wearing of gloves may interfere with any delicate procedure. Hold lengths of glass tubing vertically when carrying them to the place of work. Make sure, you know how to deal with any cuts or burns.

Equipment required 6 mm medium- or thin-wall borosilicate glass tubing cut to the required length and flame-polished at both ends, heat-proof bench mat, Bunsen burner, water-repellent marker pen, matches.

Procedure

- Place one end of the glass tubing at the top of the roaring Bunsen flame and lower it so that it is just above the blue cone. Rotate and keep it there until the end of the glass slightly melts. (Figure 1)
- Remove the tubing and look directly at the molten end. The hole should be gradually closing. Continue the process until the hole is nearly closed but not quite.
- Turn the Bunsen collar so that the luminous flame is present and hold the tube in the flame to slightly make the end of the tube black with carbon.
- Leave the tubing on the bench mat to cool. Add a rubber teat to the wider end.

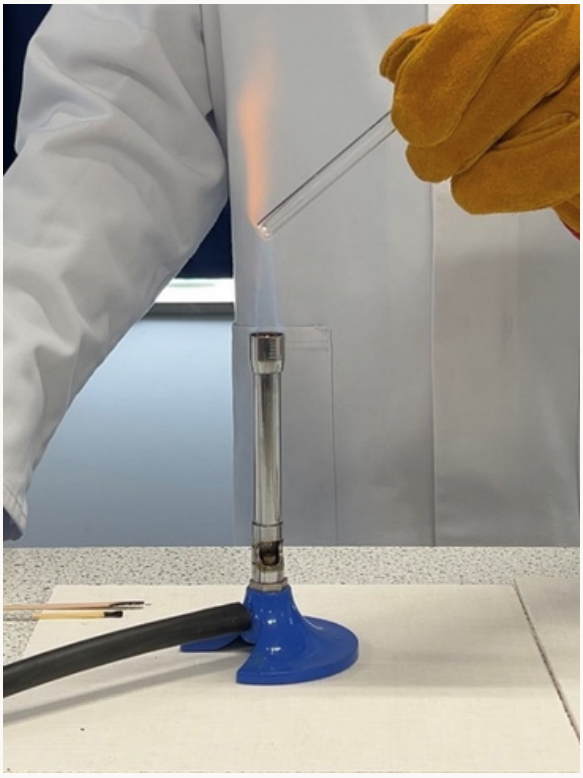


Figure 1

Additional information

The pipette can be calibrated. Place a 100 cm^3 beaker containing 50 cm^3 of water on the balance and tare the reading. Carefully remove a known mass of water, e.g. 1 or 2 g. Lift the pipette out of the water and mark the level of the water in the tube with a water-repellent marker pen.

Procedure time

Insert the time taken to carry out this procedure.

Further comments

Please use the below space to make any additional comments you have on the procedure

4.3 Making a Pasteur pipette

Hazards Sharpness of glass. Very hot glass tubing. .

Control measures Wear eye protection. Gloves can be worn, but the wearing of gloves may interfere with any delicate procedure. Hold lengths of glass tubing vertically when carrying them to the place of work. Make sure that you know how to deal with any cuts or burns.

Equipment required 6 mm medium-wall borosilicate glass tubing cut to twice the required length and flame-polished at both ends, heat-proof bench mat, glass cutter, Bunsen burner, water-repellent marker pen, matches.

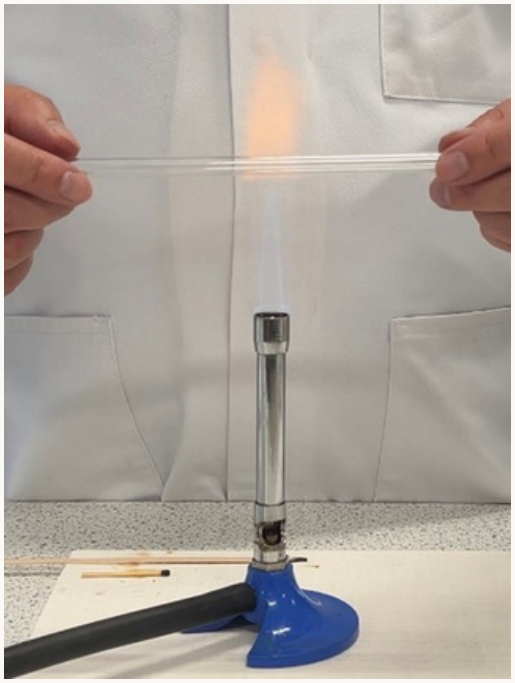


Figure 2

Figure 3

Procedure

- Place the middle of the glass tubing at the top of the roaring Bunsen flame and lower it so that the middle of the tube is directly over the blue cone. Rotate and keep it there until the glass begins to soften (Figure 2).
- Keep revolving the glass in the flame, remove it and quickly, in one movement, pull the two ends of the glass so that it is extended by about 10 mm (Figure 3).
- Leave the tubing on the bench mat to cool.
- Now cut the glass tubing in the middle and flame-polish the cut ends, ensuring not to close the hole.
- Add a rubber teat to the wider end.

Additional information

You have to cut the very narrow tubing with great care, as the glass is now thinner.
The pipette can be calibrated. Place a 100 cm^3 beaker containing 50 cm^3 of water on the balance and tare the reading. Carefully remove a known mass of water, e.g. 1 or 2 g. Lift the pipette out of the water and mark the level of the water in the tube with a water-repellent marker pen.

Procedure time Insert the time taken to carry out this procedure.

Further comments
Please use the below space to make any additional comments you have on the procedure

4.4 Bending glass tubing or rod

Hazards Sharpness of glass. Very hot glass.

Control measures Wear eye protection. Gloves can be worn, but the wearing of gloves may interfere with any delicate procedure. Hold lengths of glass vertically. Make sure that you know how to deal with any cuts or burns.

Equipment required 6 or 7 mm medium-wall borosilicate glass tubing or rod of the required length and diameter and flame-polished at both ends, heat-proof bench mat, Bunsen burner, matches.

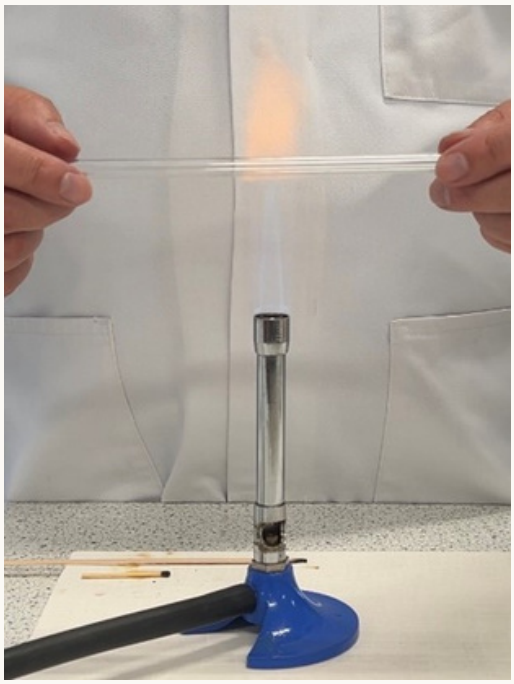


Figure 4

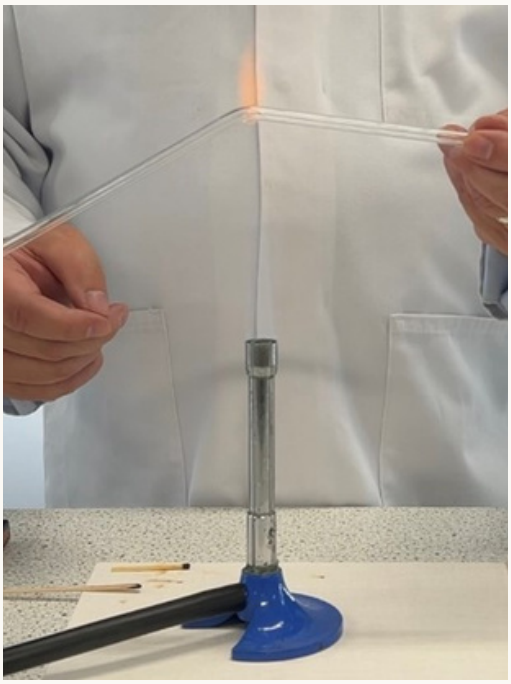


Figure 5

Procedure

- Light the Bunsen and adjust the flame to the non-luminous flame.
- Hold the glass rod or tube in both hands over the top of the flame and lower it until it is just above the blue cone (Figure 4).
- Turn the glass slowly.
- When the glass begins to soften, stop rotating and, if possible, let the glass bend under its own weight (Figure 5).
- Turn the Bunsen collar so that the flame is yellow and let the bend cool until carbon is deposited on the glass.
- Remove the glass and place it on the bench mat to cool.

Additional information

If the bend is close to the end of the tube then use a spatula or a cork borer to gently bend the softened glass. However, this can damage expensive equipment. It is better to make the bend in the middle of the tubing and then cut to the required length.

Do not take the bend more than 90°. This avoids the glass becoming too thin on the outside of the bend. Thin-wall glass collapses when bent so medium-wall is used. For a U-bend, make two right-angle bends close together.

Do not be tempted to rush any procedure.

Procedure time Insert the time taken to carry out this procedure.

Further comments

Please use the below space to make any additional comments you have on the procedure

4.5 Making stirrers

Hazards Sharpness of glass. Very hot rod.

Control measures Wear eye protection. Gloves can be worn, but the wearing of gloves may interfere with any delicate procedure. Hold lengths of glass rod vertically when carrying them to the place of work. Make sure that you know how to deal with any cuts or burns.

Equipment required Glass rod (soda glass should be used if the rod is greater than 7 mm in diameter) cut to the required length and flame-polished at one end, heat-proof bench mat, Bunsen burner, matches.

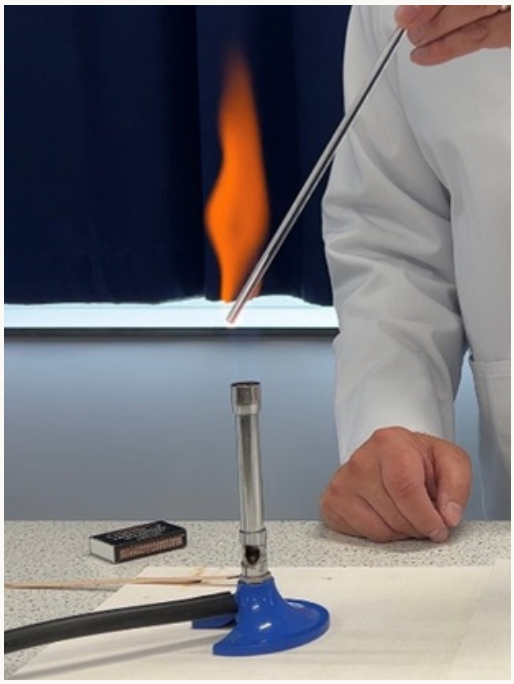


Figure 6

Figure 7

Procedure

- Light the Bunsen and adjust the flame to the luminous flame.
- Place the non-polished end of the glass rod into the flame and turn the air-hole on the Bunsen burner slowly so that the non-luminous flame is now heating the glass (Figure 6).
- Rotate the rod quickly so that the glass does not droop and, when soft, quickly remove the glass from the flame and press it firmly on the bench mat to produce the stirrer (Figure 7).
- Adjust the flame to luminous and hold the rod in the flame until it is coated with carbon.

Additional information

Other designs are possible. For instance, tongs can be used to squeeze and bend the glass into a golf-club shape.

Procedure time Insert the time taken to carry out this procedure.

Further comments
Please use the below space to make any additional comments you have on the procedure

4.6 'Drilling' a hole in a rubber bung

Hazards 0.4 mol dm-3 sodium hydroxide solution is an IRRITANT to the eyes and skin.

Control measures Wear eye protection. The bung should be placed with the largest area on the bench mat so that it is in a more stable position.

Equipment required Cork borers, cork borer sharpener, rubber bungs, bench mat, 100 cm^3 beaker, 0.4 mol dm-3 sodium hydroxide solution, the glass tubing or thermometer that is to fit in the hole.

Procedure

- Find the cork borer that just slips over the tube or thermometer.
- Now select the next size smaller to bore the hole.
- Place the rubber bung on the bench mat (Figure 8).

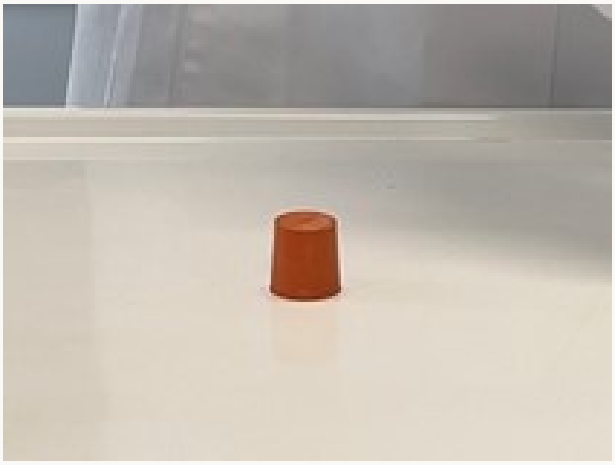


Figure 8

Figure 9

- Place a little sodium hydroxide solution in the beaker.
- Place the borer in the cork borer sharpener (Figure 9), close the knife and sharpen the end.
- Dip the sharp end of the cork borer in the sodium hydroxide solution. Place the cork borer on the bung. Hold the bung between finger and thumb and twist the borer into the bung (Figure 10). If it becomes difficult to make progress through the bung, remove the borer and insert it again, driving more alkali into the bung.
- When through, remove the borer from the bung and take out the waste rubber from the cork borer.
- Clean the cork borer and the rubber bung with absorbent paper.

Figure 10

Additional information

Sodium hydroxide solution reacts with rubber and softens it. It is safer to buy pre-drilled bungs if a suitable size is available.

Procedure time Insert the time taken to carry out this procedure.

Further comments
Please use the below space to make any additional comments you have on the procedure

4.7 Inserting glass tubing (or a thermometer) through a rubber bung

Hazards Sharpness of the glass tubing if it breaks.

Control measures Wear eye protection. Make sure that the end of the glass is not pointing towards your hand. The tubing must be flame-polished.

Equipment required Cork borers, bench mat, rubber bung with a hole in it, glass tubing or thermometer, soap solution.

Procedure

- Place the bung with a hole through it on the bench mat with the larger diameter end on the mat.
- Choose the cork borer through which you can just insert the tube or thermometer. Place a tiny amount of soap solution or liquid detergent on the end of the chosen borer.
- Insert the borer all the way through the bung (Figure 11).
- Fit the glass tube through this cork borer (and the bung) (Figure 12). You may need to adjust the length to which the tube is inserted.
- Withdraw the cork borer, and the glass tube or thermometer is inserted through the bung. Adjust as necessary and wipe off any excess soap.

Figure 11

Figure 12

Additional information

This procedure, if performed poorly, can result in some very nasty accidents, the worst being glass tubing penetrating the hand.

Procedure time Insert the time taken to carry out this procedure.

Further comments
Please use the below space to make any additional comments you have on the procedure

Removing tubing from bungs

Hold the tubing in one hand and the bung in the other. Try to move the bung along the tubing; the movement should be parallel to the tubing. If it moves a little, detergent can be applied but, as soon as resistance is such that the bung movement becomes difficult, the glass and bung should be thrown away. If you have to 'waggle' the bung in any way, then lateral stress is being applied to the tubing and the glass can break. If that is the case, again the glass should be disposed of.

Alternatively, tubing can be removed by reversing the cork borer technique. Select a cork borer that just fits over the tube. Slide the hand borer over the tube and, with a back-and-forth twisting motion, work the borer through the bung (using detergent). The tubing can then be removed and a new tube placed into the borer. This is especially useful if you are removing a thermometer.

4.8 Blowing a hole in a test tube

Hazards Very hot apparatus.

Control measures Wear eye protection. Ensure that there are no cracks in the test tube.

Equipment required Medium-wall borosilicate test tube, stopper to fit it, Bunsen burner, heat-proof bench mat, matches.

Procedure

- Place the Bunsen on the bench mat and set the flame to non-luminous.
- Place the end of the test tube in the flame and let it get very hot (Figure 13).
- Insert the bung into the test tube.
- Keep the test tube in the flame and the expansion of air will blow the hole. There may be a little 'pop' sound.

Figure 13

Additional information

This procedure can be used to make combustion tubes. The size of the hole is very important. If it is too small, it is very difficult to ignite the natural gas as it comes through.

A creme brulee burner (available from kitchenware stores) provides a narrow, hotter flame and may be easier to work with.

Thin-wall test tubes are not suitable as the molten glass gets even thinner on expansion. Do not blow into the test tube as this produces very thin slivers of glass.

Do not be anxious! The noise generated as the hole appears is quieter than a hydrogen 'pop'.

Procedure time Insert the time taken to carry out this procedure.

Further comments

Please use the below space to make any additional comments you have on the procedure

4.9 Inserting wire into glass tubing

Hazards Hot glass may cause burns.

Control measures Wear eye protection.

Equipment required 6 mm medium-wall borosilicate glass tubing flame-polished at one end, nichrome wire, retort stand, boss and clamp, tongs, Bunsen burner, heat-proof bench mat, matches.

Procedure

- Place the Bunsen on the bench mat and set the flame to non-luminous.
- Set up the retort stand, boss and clamp and place the nichrome wire in the clamp so that the wire is horizontal.
- Position the wire by moving the boss so that the end of the wire is in the hottest part of the flame.
- Push back the Bunsen burner, hold the glass tubing with the flame-polished end and move the tubing so that the wire is inserted into the tubing.
- Bring the Bunsen back into position so that the end of the glass melts (Figure 14).
- When the glass is soft, use the tongs to crimp the glass around the wire.
- Turn the flame to luminous so that the glass cools slowly.

Figure 14

Additional information

This is useful for making a flame wire holder. Soda glass must never be used for this piece of equipment.

Procedure time Insert the time taken to carry out this procedure.

Further comments

Please use the below space to make any additional comments you have on the procedure

4.10 Repairing chipped glassware

Hazards	Sharpness of glass. Very hot glass.
Control measures	Wear eye protection. Gloves can be worn, but the wearing of gloves may interfere with any delicate procedure.
Equipment required	Bunsen burner (or creme brulee burner), wire gauze, spatula, tongs, heat-proof bench mats, dustpan and brush, retort stand, boss and clamp, matches.
Procedure	• Place the Bunsen on the bench mat. • If there are jagged edges on the glass, use the wire gauze to shave away the glass until it is reasonably smooth. Clean up the glass with the dustpan and brush. • Clamp the glass object so that you can work on the glass with the flame. • Light the gas, turn the flame to luminous and gradually warm up the glass. • Gradually turn the air-hole to open and melt the glass edges. You might find the focused hotter creme brulee burner flame is easier to work with. • You can use the spatula and tongs to help with any crude shaping. • When you have finished the work, turn the flame to luminous and blacken the worked-on sections of glass.

Additional information

The repair may not work. Colour code repaired glass so that this equipment is not heated directly with a flame.

A repaired measuring cylinder or beaker will still hold a liquid at room temperature.

A similar technique can be used to seal a broken burette. Use tongs to seal the glass. These make useful collecting vessels. Burettes are usually made of soda glass so you have to warm up and cool down the glass very slowly. A Bunsen burner is probably better for this work.

Procedure time Insert the time taken to carry out this procedure.

Further comments

Please use the below space to make any additional comments you have on the procedure

4.11 Procedure template

The template below can be duplicated several times, so that you can add other pages of techniques as you develop your skills.

Title	
Hazards	
Control measures	
Equipment required	
Procedure	
Additional information	
Procedure time	
Further comments	

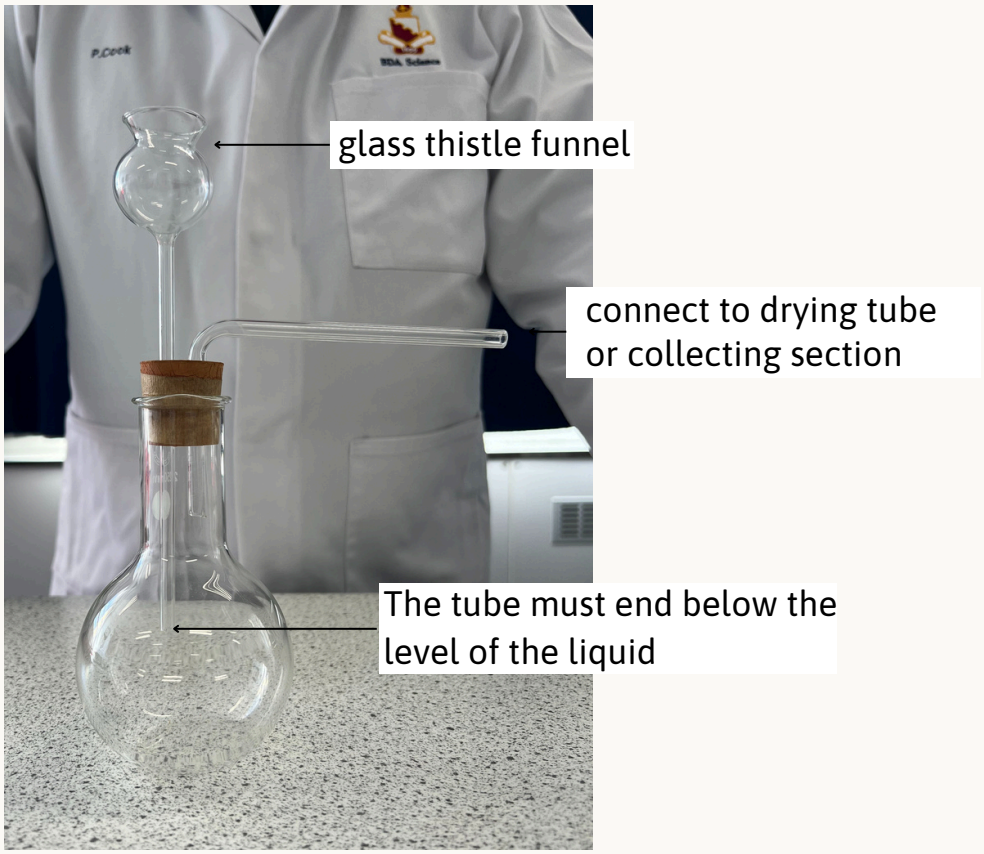
5. Projects

You will be required to make and repair equipment. This will not occur every day and techniques soon become rusty and control measures are forgotten. Write out your projects so that the procedures you develop are not lost.

5.1 Making a delivery tube

Procedure	See section
Cut and flame-polish a length of 6 or 7 mm borosilicate glass tubing.	4.1
Bore hole(s) into any bungs and thread the glass tubing through.	4.6 and 4.7
Bend the tubing to the required lengths.	4.4
Cut and flame-polish the ends if required.	4.1

5.2 Gas preparation equipment



Procedure	See section
Cut and flame-polish a short length of 6 or 7 mm borosilicate glass tubing.	4.1
Make a right-angle bend in this tubing to allow the gas to pass to the drying tube or collecting section.	4.4
Ensure that the glass thistle funnel is long enough to fit almost to the bottom of the reaction flask.	
Bore two holes into the bung that fits the reaction flask and thread the thistle funnel and the 90˚ bend glass tubing through. The size of the bung needs to be a size smaller than fits the neck of the flask normally, due to expansion of the bung when the glass tubing is inserted.	4.6 and 4.7

The ASE is grateful to the Worshipful Company of Glass Sellers Charity Fund, whose funding has made this resource and accompanying films possible. The Worshipful Company of Glass Sellers has had no input into the content or delivery of the resources or films.