Yes you can! ASE Health and Safety Group presentation to the 2015 Annual Meeting

Yes! You can

Notes from the session at the ASE Annual Meeting January 2015. 10.30 Friday January 9th.

The demonstrations, in order of presentation:

Using phenolphthalein, a known carcinogen, safely and usefully in school science.

Demountable transformer

Safe microbiology practice

Power line demonstration

Half-life of radon demonstration

Butane bubbles

Taking and studying blood cells

Contained combustion of ammonium dichromate

Conductivity of hot glass

The whoosh rocket

The exploding can of volatile, solvent-based glue,

Yes! you can.

The purpose of the presentation is to encourage practical science by helping teachers and technicians identify safe ways of working, and also to help develop new, exciting, and safe practical activities. This has always been the ambition of the ASE Health and Safety Group (formerly the Safeguards in Science committee).

Fundamental to the presentation is the idea that the implementation and increased use of the risk assessment helps science staff preserve and, in some cases, reintroduce, valuable and effective practical activities in the science curriculum.

This is in contrast to the *perception* that health and safety in general, has reduced the number and variety of practical activities which can now be undertaken in schools and colleges. The idea that H&S is a limiting factor in the scope of practical work in schools and colleges has a strong purchase in the minds of many science educators. To reinforce this point CLEAPSS, working with and for the RSC (Royal Society of Chemistry), undertook to survey in 2005 the perception of banned school science activities. This resulted in the RSC publication *Surely that's banned!* And a CLEAPSS guidance leaflet (PS 69 – *Banned chemicals and other myths*) The ASE H&S Group which shares several members with both CLEAPSS, the RSC, and SSERC in Scotland, is, therefore, well aware of the impact of H&S on whether or not some practical activities are performed or not in schools.

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You will note that we are not using a laboratory for this session in order to make it easier for delegates to attend. To accommodate the venue we have had to adapt the risk assessment for the demonstrations we plan to perform. We have also had to import fire extinguishers, a fire blanket, buckets of water, covers for the carpet, and equipment to deal with spills. In one or two cases we have been unable to make sufficient adaptation so you will not see a demonstration of the thermit reaction, nor of the exploding methane can. This illustrates an important point about model risk assessments. They must be adjusted by the practitioner in the light of local circumstances to ensure safety at all times. Adjustments need not always mean that an activity should not be undertaken. There are instances where the model risk assessment might suggest an activity is suitable for a Y9 class. However, towards the end of Y8 there are undoubtedly some classes whose collective experience and expertise would allow such a activity to be undertaken perfectly well. (see Topic 10 *Topics in Safety* ASE for further information about adapting model risk assessments when using chemicals)

We should also point out that the demonstrators today are very experienced and also have had a great deal of time too prepare. In schools, many teachers are not necessarily so experienced and it would be folly to suggest there is much time either for preparation or clearing away. It is likely that in schools most practical work is impossible outside of a laboratory.

We will begin with an activity using phenolphthalein which is NOW known to be a carcinogen and it has been suggested should therefore not be used in school because there are alternatives. But it is used in dilute solution – in ethanol – so it is highly flammable but that has never stopped us using it – you just keep it away from naked flames.

Phenolphthalein:

- Used as an indicator in titrations gives much the clearest end point, and in some circumstances eg weak acid/strong alkali it is the only indicator you can use.
- The solid is now known to be carcinogenic but at the concentration used for indicator purposes, it is classes as low hazard, and the risk is small especially when the tiny quantities used are taken into account. The solution is only classed as carcinogenic if >1%. The CLEAPSS Recipe Book gives 0.1% but some commercial samples may be more concentrated.
- Strictly speaking using a CLEAPSS solution, no control measures are necessary – except keeping away from naked flames. [Quick demo of NaOH, acetic acid & phenolphthalein for the benefit of any non-chemists]
- The activity is written up in SSR, March 2013, page 12 (free to members on the website). There are some circumstances where the risk from phenolphthalein is much greater because of the nature of the activity and more control measures are necessary. Put on gloves because in this demo we are squirting 2 ml or so of the solution onto a lump of concrete, so skin contact is much more likely than when adding a few drops to a conical flask (note that the SSR article did not mention the need for gloves because, at the time, phenolphthalein had not been classed as carcinogenic). Cries of "Boring" when nothing appears to happen. Then take a hammer and put lump of concrete on the floor (on an old newspaper) and put on eye protection (protection from flying fragments) and smash

the concrete. Quickly squirt phenolphthalein solution on to the newly-exposed surface. It goes bright pink (but fades quite quickly as CO_2 neutralises the exposed CaO). If you look carefully, you may see a "shell", perhaps 1 or 2 mm deep where the CO_2 had slowly penetrated the bulk of the concrete. Other things being equal, the older the sample of concrete, the deeper the penetration. So if the police find a body under the patio, they can work out whether you did it or a predecessor in your house!

- The key to its use is adjusting the risk assessment

(For further information see Topic 10 from the ASE publication *Topics in Safety*. The revised version of this Topic is expected to be published on the ASE website in February or March 2015.)

The demonstration using a demountable transformer was another widely practiced demo which is much less common nowadays. The demo includes melting a nail, welding two nails together, and melting solder, as in a simple induction furnace, showing the transfer of energy by magnetic induction, and how powerful an electromagnetic field can be using the 230 volt ac mains supply across the primary coil. This is another example of a demonstration which requires skill and expertise on the part of the demonstrator and which many teachers today do not feel they have. Because hazards are involved, it has become assumed that the demonstration is no longer allowed on grounds of health and safety. In fact there are no such grounds, and the hazards can be dealt with by following a risk assessment. (Instructions and risk assessment can be found in the CLEAPSS guidance leaflet GL112 *Using a demountable (dissectible) transformer*.)

Microbiology work in schools is fraught with misunderstanding, which leads to avoidance, to the detriment of children's learning. The principles which govern safe microbiology practice are:

- Begin with sterile materials and equipment (except of course the source of microbes). Sterilisation is achieved using heat, for which an autoclave or pressure cooker is necessary. Without one or the other it is impossible to safely undertake microbiology practical activities.
- Conduct all activities aseptically to reduce the risk of introducing unwanted, and possibly harmful, microbes
- Do not culture microbes from known pathogenic or potentially pathogenic sources
- Ensure cultures, once inoculated, cannot escape into the environment, Reduce risk of spilling by culturing on a solid medium
- At the end of any practice exercise, destroy cultures by sterilisation in an autoclave/pressure cooker.

The practical will involve providing each member of the audience with a small, sterile nutrient agar plate onto which they can put a source of microbes such as clean/dirty finger, a swab from a nearby surface (allows us to talk about not swabbing from body orifices or toilets etc.). Audience members will close their plate and fix (not seal) the lids with sellotape. They can take them away for incubation, only if there is an autoclave or pressure cooker available at school) or leave with us for destruction. (see the CLEAPSS Laboratory Handbook, section 15.2.2, for further information on good practice and safety measures in microbiology)

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The power line demonstration illustrates quite vividly, and immediately, why it's necessary to transmit electricity at quite high, and more hazardous, voltages. In the past, teachers made use of available equipment to build a model power line to show the effect. Unfortunately attempts at realism often involved the use of quite long, bare wires for power lines. Touching bare wires at 230 volts is obviously very dangerous, but, inadvertently, too many teachers did. However, it is not difficult to produce a safe working model. A simple analysis of the hazards identifies that live contacts at 230 volts are dangerous. The solution is to insulate all such contacts so that they cannot be touched. This is, of course, the outcomes of a risk assessment. In the demonstration we used a set of proprietary equipment sold by *Electrosound*, which is designed to be safe. (Other suppliers, such as Irwin, sell similar equipment)

The word 'radioactive' generates huge fear, and, with a little embellishment any radioactive substance can be made to appear too hazardous for any sane person to contemplate using it or being involved with it. A role for science education is to teach pupils about radioactivity so they can engage in a meaningful way with the debate over the use and value of radioactivity. This cannot be done by theory alone. Simple, safe practical activities illustrate more powerfully than any other means some of the important aspects of the debate. The half-life of radon demonstration is one example. It involves a sound knowledge of the hazards and how they can be controlled both in keeping radioactives in school and in using them in the classroom. In addition, holding and using radioactive materials is governed by some dedicated regulations which must be followed. The demonstration uses thorium which is widely regarded as banned, although it isn't. However, we do not recommend fine powder thorium compounds, but certain gas mantles (available from hardware and camping shops) are thoriated and provide a simple and readily-available source of the radioactive material. Teachers are often easily persuaded that, despite the obvious benefits of a live demonstration, working with radioactives is too difficult/dangerous/demanding to be considered. A video might be a safer option. For those teachers and all others, there is clear, and straightforward advice which enables all the hazards to be controlled and the regulations met. (Instructions and risk assessment can be found in the CLEAPSS guide GL 128 - *Measuring & demonstrating radioactive half-life*)

Combustion is an important idea in science. It is also entertaining. Lighting bubble of combustible gas is a memorable demonstration which both teachers and children appreciate. The main objective of the demonstration is to show that when a gas less dense than air burns, almost all the heat goes upwards. Normally performed with methane gas (see the CLEAPSS Supplementary Risk Assessment 03), at the meeting we used butane gas, which is much denser than both methane and air. Hence it does not rise in the same way methane does. Since the demonstration at the ASE meeting, and a reported accident where the participant received significant burns, we have reviewed our risk assessment and have concluded that the use of butane gas presents too many hazards to be considered sufficiently safe for schools.

Taking and studying blood cells illustrates the, perhaps, unintended consequences of regulation brought in to deal with a perceived hazard. It also illustrates the fact that such regulations can be successfully challenged and countered over time. In the '80s, a common practical was to enable pupils to take a sample of their own blood in order to check their blood type (A, B, AB or O). In addition, looking at a fresh blood sample using a microscope provided a vivid means of seeing the shape and density of red blood cells and the comparative rarity of white blood cells. Since every one of us has plenty of blood, taking a small amount for useful study never seemed much of an issue. That is until the onset of HIV/AIDS which can be transmitted through contaminated blood. The risk of such transmission in a school practical is relatively easy to control but the whole notion of HIV/AIDs caused considerable fear and anguish among a large proportion of the UK population at the time (late 80s / early 90s). A Government statement to the effect that deliberate blood (and cheek) cell sampling, with its risk of human cell transfer from one person to another was too risky to be considered valid in schools. From this, most local authority and a few other education employers banned the practice. Subsequently a well-considered , risk assessed and publicised procedure restored the practical involving taking and studying cheek cells, mainly because the process was entirely non-invasive (cotton buds don't easily cut people and can be very easily disinfected prior to disposal). Taking blood is never non-invasive, but can be accomplished quite safely with care and following a suitable risk assessment. Most employers have rescinded their erstwhile bans. Therefore, this very valuable practical is, once again, available to teachers, because of a sensible risk assessment. (Information and risk assessment is available in the CLEAPSS *Laboratory Handbook*, chapter 14, section 14.4. A model letter to parents requesting permission can be found in the CLEAPSS customisable documents (web site) DLH 14-4. Eldon cards, as used in the demonstration, are available from a number of science suppliers, such as Blades Biological, and also Amazon).

The combustion of ammonium dichromate (CLEAPSS members should see *Hazcard* 7 for the long list of hazards and risks associate with this compound; in Scotland, SSERC members should check the ammonium dichromate entry in the Hazardous Chemicals Database) is interesting, in that the amount of product appears greater than the amount of material started with. However, ammonium dichromate is toxic and a carcinogen so its combustion needs to be carefully controlled so that neither teachers nor students are at risk from the reaction. As we are using crystals there is negligible risk of inhaling and little risk of skin contact. You could wear gloves but arguably you are more clumsy and hence more prone to accidents. A momentary contact with the odd crystal will not cause a problem but as we are doing this in a non-lab you need to have a bucket of water available to instantly rinse off any contact. The decomposition product, chromium(III) oxide is NOT hazardous but it is possible that a few specks of undecomposed ammonium dichromate might be present in the chromium(III) oxide fountain, with the possibility of being inhaled (but remember until relatively recently it was commonly used in indoor fireworks). We don't know how likely this is but we have to assume there may be a problem so it must be impossible to inhale the decomposition products. So use a fume cupboard (not available in this non-lab) or contain it in some other way. For this demo we are going to contain the reaction inside a conical flask which is plugged with ceramic wool to contain all particles. Do not use a cork or bung for a stopper as the reaction produces large volumes of nitrogen and water vapour which would blow any bung out.

Weigh out 2 – 3 g of ammonium dichromate. Take a 1 – 2 litre conical flask and, using a tube (made from rolled up paper if you have no other) pour the dichromate into the flask so that it is, as far as possible in a pile. Insert a plug of ceramic wool in the neck of the flask. Place the flask on a tripod and heat with a Bunsen burner. You will see it begin to darken and then a few sparks will appear. At this point, remove the Bunsen burner and the reaction will continue on its own: a small fountain of orange sparks and dark green powder will be visible until all the dichromate is used up. You will also see steam coming out through the ceramic wool at the top.

An interesting demo from the past is not often carried out nowadays. The conductivity of hot glass vividly shows how the properties of a commonplace substance can be altered by its physical state. The demonstration helps make the point that properties of materials can appear fixed but the reality is much less clear-cut. It's an important point for children (and often adults) to recognise. The practical was originally described using mains electricity, connecting a mains heater, a mains tungsten lamp and a glass rod connected in series. The glass rod had bare copper wire connections to it. This arrangement is very hazardous, the bare conductors being at mains voltage. The same practical can be carried out equally effectively at 30 volts using a high brightness LED. (Instructions and risk assessment, SRA23, can be obtained from CLEAPSS)

A relatively new addition to the curriculum - the whoosh rocket, is an alternative demonstration to the whoosh bottle, which is probably performed at least once a year in most secondary schools, often at parents' evening and sometimes in a visit to a primary school. The whoosh bottle demonstration is spectacular, and it can go spectacularly wrong if the instructions/ risk assessment are not followed exactly. It does demonstrate that, again contrary to popular belief, H&S is not restricting practical work but enabling it. Instructions and risk assessment can be found in CLEAPSS Supplementary Risk Assessments; SRA 22, or on the SSERC website under Chemistry Demonstrations).

A smaller scale version of this, which is still exciting, is to use a 2l fizzy drink bottle which is propelled by the hot gases from the alcohol combustion. In order to have control of the direction of the 'rocket', and to allow the use of light gates or other methods for measuring its speed (constraining the path makes this easier) it is run along a guide 'wire'.

Take a 2l fizzy drink bottle (empty) and make a hole in the base of 5 – 6 mm (using a heated cork borer, a screwdriver or a drill). Find a bung to fit the hole and make sure the bottle lid is firmly screwed on. Take a length of string, long enough for the length of the room – nylon fishing line is particularly good as it is smooth. Fix it firmly at one end – either to an existing fitting or screw a cup hook into a wooden door/window frame). For the 'runner' use a straw or, better, a length of glass tubing. Thread the 'wire' through the runner **before** pulling it as tight as you can and fastening it to the other end. You will now have a 'wire running the length of the room with a runner free to run along its length.

Place about ½ to ¾ cm^3 of ethanol (methylated spirit) in the bottle, replace the bung, and swirl it round for a minute or so to evaporate. Use sticky tape to firmly fix the bottle to the runner, so the bottle is now hanging below the thread. Remove the bung and apply a flame to the hole. The gases will ignite and with a whoosh, the bottle will hurtle across the room at great speed.
(Detailed instructions can be found on the SSERC website -

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http://www.sserc.org.uk/index.php/chemistry-demonstrations/chemistry-demonstrations/3423-ethanol-rocket

Finally, the exploding can of volatile, solvent-based, glue is an interesting demonstration which not widely known or used in schools. It is quite straightforward and presents few hazards. A syrup tin or similar is drilled to take two 4 mm plug sockets in the walls. A coil of nichrome wire is connected between them, to act as a heating coil. A piece of scrap paper, not much bigger than a postage stamp, is coated on one side with a non-aqueous solvent based glue (eg Evostick or similar; look for the flammable diamond symbol on the packet). The lid is pressed on tightly, left for a few moments for the solvent to evaporate and then a current from a low voltage power pack passed through the wire (usually about 12 V is necessary but the supply must be capable of delivering a current of around 8 A so that the wire glows red hot. Not all low voltage power packs can deliver sufficient current to get the wire hot enough). The hot wire ignites the explosive air/solvent mixture, again blowing the lid off. The chemistry of this demonstration is essentially the same as the Whoosh bottle but because it is not a routine demonstration in schools you would need to apply to CLEAPSS for the Special Risk Assessment which is held on file.

So H&S should not be considered to restrict practical science but, in fact, to support it. An appropriate risk assessment lets you undertake almost any practical work you like, provided you follow the instructions. The ASE will continue to work on your behalf to ensure that, one way or another, you can easily find a risk a risk assessment for that exciting practical you want to do, or if you are really wanting to be innovative, will find a way of providing you with one. Don't believe the doomsayers. Whatever the question on practical science, the answer is probably Yes! you can.