


# SSERC *Bulletin*



Ideas and inspiration supporting science and technology for all Local Authorities

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# Auditing your radioactive sources

**In Bulletin 255, we reminded users of radioactive materials in schools of the administrative procedures they should be carrying out in order to work safely and comply with the law. In this issue, we look at the sorts of sources that are permitted for use in schools.**

If your school possesses something other than a permitted source, please get in touch with SSERC immediately; we will be able to help. Please always rely on our advice regarding what is permitted. "Complies with all legislation" or "no permission required to purchase" are phrases that may well be true for a source on sale, and destined for use in America or even England, but they may not be applicable to Scotland.

## 1) "Standard" source

At present, these are the most common sealed sources in use in schools. They have been supplied by Griffin, Harris, Irwin, Nicolson for decades and are still available from Harris. The only ones that should still be in schools are americium ( $^{241}\text{Am}$ ), strontium ( $^{90}\text{Sr}$ ) and cobalt ( $^{60}\text{Co}$ ), respectively used to demonstrate the properties of  $\alpha$ ,  $\beta$  and  $\gamma$  radiation. The sources are stored in lead-lined pots in hardwood boxes. Typically, these sources have activities between 3.7 kBq and 185 kBq.

These sources require to be handled by tongs. They have an excellent safety record and have now been shown to comply with ISO 2919. There were also radium and plutonium sources of this design in use in schools. Most, but not all of these should have been disposed of. If you discover that you still own some, please contact the RPA.

## 2) Hi Tech/QSA Global source

Many schools re-equipping with sealed sources are opting for this type. They are available as  $^{241}\text{Am}$ ,  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ ,  $^{22}\text{Na}$ ,  $^{90}\text{Sr}$ , but the sodium source is not to be used in schools - **do not buy it**. The properties of gamma radiation can be studied with either  $^{60}\text{Co}$  or  $^{137}\text{Cs}$ . Typically these sources have activities between 74 kBq and 370 kBq. The sources can be handled without tongs and come with their own storage pots. They can be mounted in standard boss heads. These sources comply with ISO 2919.

## 3) Cooknell ionisation chamber with thoriated gas mantles

Some, though not all, gas mantles have been thoriated. Thorium decays to radon ( $^{220}\text{Rn}$ ), also known as thoron. This isotope of radon has a half life of 54 s.

The mantles are kept in a plastic bottle that can be connected to an ionisation chamber. The radon is transferred to the chamber by loosening a clip and squeezing the bottle. The small current between the electrodes in this ionisation chamber is proportional to the activity of the radon. It is amplified by an extra-high impedance amplifier. The output can be displayed on a voltmeter or data logger.

## 4) Caesium/barium isotope generator

This source is used to demonstrate half life. Using a process called eluting (effectively "washing out"), a special fluid is passed through the generator, which contains beads impregnated with  $^{137}\text{Cs}$ . The caesium itself is not washed out, but a radioactive isomer of barium,  $^{137\text{m}}\text{Ba}$  passes with the liquid into a glass receiving vessel. The barium decays, with a half life of 2.6 minutes, to a stable form of the same isotope. Thus, after half an hour, the liquid is not significantly radioactive and can be disposed of down a drain.

There are two forms of this generator available, with activities of 33 kBq and 370 kBq - **do not buy the latter or the Pasco "10 microcuries" source and if you have one, please let us know**. As well as a leak test, this source requires a simple annual "bleed through" test to check that no caesium is being removed from the generator during elution.

## 5) Protactinium generator

The protactinium generator consists of approximately 1.5 g of uranyl nitrate in concentrated hydrochloric acid plus an organic solvent, hexyl ethanoate, that is immiscible with water. This is contained in a sealed bottle. Protactinium-234 has a half life of around 70 seconds and is an element in the decay series of



Figure 1 - Sources for use in Scottish schools.

uranium-238. When the generator is shaken, protactinium is taken up by the organic solvent. When the liquids settle, the organic solvent bearing the protactinium remains in a layer at the top. When not in use or when being transported, the protactinium generator is stored within a larger bottle, within which it rests on a foam pad.

The activity of the protactinium generator is estimated to be in the region of 20 kBq but much of the radiation will be absorbed by the container and the liquid within it. The protactinium decays by emitting beta particles whose energy spectrum peaks at 2.3 MeV. These can penetrate the walls of their container.

Note that you might have significant "end of life" disposal costs with this source due to the chemical toxicity of the uranium. The recommended working life of this source is 8 years. **Do not make your own protactinium generator.**

### 6) Frederiksen cloud chamber source

This americium source ( $^{241}\text{Am}$ ), with an activity of 3.7 kBq, is designed for cloud chambers.

### 7) Thoriated TIG welding rods

Some TIG (tungsten inert gas) welding rods contain small amounts of thorium. This makes them ideal as sources for use in cloud chambers. The rod in the picture is a few cm long and comes

with Lascell's Peltier-cooled cloud chamber, as given to all local authorities by SSERC in 2015. The activity of these rods is likely to be around 3 kBq. If you have a radioactive sources storage cabinet, keep them there. If not, it is OK to store them with the cloud chamber. **Do not saw or grind the rods.**

### 8) Radioactive minerals

These rocks are for showing that some minerals are naturally radioactive. They should not be used to demonstrate the properties of radiation, for example absorption, because, where possible, you are obliged to work with a sealed source and the aforementioned investigation could be done using such a sealed source.

Note that the rocks should not be taken out of their bags.

You are also allowed to have a smoke alarm in order to show that it contains a radioactive source. You must not take it apart or use the source for experiments. Some schools have objects made of uranium glass. This is fine but in general don't accept or bring in radioactive items from home or elsewhere. This includes glow-in-the-dark watches and dials. Any uranium or thorium compounds should have been disposed of. These still turn up in chemical stores, unfortunately. Keep a special eye out for sachets of thorium compounds in polythene "radon generator" bottles. We have never sanctioned the purchase of the disc-shaped Pasco sources because they have not been shown to comply with ISO 2919. We will now not authorise the purchase of the acrylic-handled Frederiksen sources for the same reason. As we said, if you find anything you don't think you should have, please get in touch. ◀

# Chemical Store

## Storage of chemicals in

**We continue to come across cases where the storage of chemical is causing some concern. It is important that we highlight that there are a number of pieces of legislation that require chemicals to be stored and handled safely - e.g. Health and Safety at Work etc. Act 1974, Management of Health and Safety at Work Regulations 1999, Control of Substance Hazardous to Health Regulations 2005 (COSHH), the Dangerous Substance and Explosive Atmospheres Regulations 2002 (DSEAR).**

In some situations, we feel that those responsible for the design of accommodation or management of premises are not fully aware of either the legislation or the importance of compliance

In general, chemicals should be kept in a dedicated indoor store, preferably accessed from the main prep room but if not then conveniently close to it. This arrangement increases security and reduces manual handling problems. Such internal stores should be large enough to allow the separation of incompatible substances. It is not necessary to have an additional outside store since these can be a security risk and often results in manual handling issues. The only reason for having an outside flammable store would be if you had in excess of 50 l of flammable liquids a situation which should not arise. If flammables are to be stored, a risk assessment under DSEAR should be carried out to assess whether an explosive atmosphere could develop. This will determine whether spark-proof electrical fittings are required - a situation which rarely occurs in the school environment. In any event, the storage of flammable materials must be approved by the local fire prevention officer and internal chemical stores should have a fire resistance of at least half an hour.

To date, the majority of the issues that we have encountered have been around the ventilation and temperature of chemical stores. All chemical stores should be well ventilated to the outside either by mechanical (e.g. electrical fan) or natural means (e.g. top and bottom venting through air bricks in external walls) and protected from frost. Siting the store on an outside wall can be an advantage and when suitable is certainly the easiest and most cost effective way to ventilate chemical stores. It is not necessary to have full air conditioning. Windows are not recommended as these present security problems and can expose chemicals to direct sunlight which is undesirable.

Unless the chemical store is used for dispensing chemicals then a ventilation rate of 2 room changes per hour should be sufficient.

To achieve this by mechanical ventilation, it is necessary to have a way of allowing 'fresh air to be drawn into the store. This is often done by having an 'in vent' low down in the door to the store. To ensure the system is efficient the extraction fan should be placed high, usually in the ceiling, as far as possible from the 'in vent'. It is also important that it is unobstructed. Unless a risk assessment under DSEAR suggests that an explosive atmosphere may develop, non-sparking fans are not needed.



# schools

Mechanical ventilation should be controlled by a separate switch, not linked to the lighting, outside the chemical store. If it is required to have a time switch, to come on for a certain period every hour for instance, there should also be a manual override.

It comes as a surprise to most people that there is no specific legislation that refers to temperature in a chemical store. It is good practice to keep chemicals relatively cool and the HSE expects employers to adopt 'good practice' when there is no specific legislation. We would recommend around 15-20°C, but temperatures in the low to mid 20s are acceptable. The issue of temperature is, however, covered indirectly. As temperature increases, volatilisation of susceptible substances, particularly organics, increases. This leads to a greater concentration of these chemicals in the atmosphere, which is covered by COSHH and DSEAR (as mentioned above). While a higher temperature will lead to shorter shelf lives for chemicals, provided the ventilation is sufficient to cope with the vapours, this is not a health and safety issue.

**It is important that decisions regarding the specification and location of a chemical store are made early in the design process: remedial works after construction has finished can be very expensive.**

**More details** around the storage of chemicals in schools can be found in a SSERC document on laboratory design, which can be downloaded here [www.sserc.org.uk/images/Chemistry/misc%20documents/SSERC\\_Lab\\_Design\\_Draft.pdf](http://www.sserc.org.uk/images/Chemistry/misc%20documents/SSERC_Lab_Design_Draft.pdf).

## Microbiology for teachers - a new course

For many years we have been running the *Level 3 Safety in Microbiology* course which is SQA accredited and which involves delegates being assessed both in practical techniques and in a formal written assessment. While it is essential for someone in school to be trained to Level 3 in this way, it is not essential for teachers to have this level of training in order to deliver the vast majority of microbiology that is in the curriculum.



Biology teachers come from a wide range of academic backgrounds with a wide range of skills and interests. We feel that it would be beneficial for teachers with little or no prior experience of microbiology to undertake a course which allows them to acquire and practise aseptic technique and various other skills required to support the delivery of microbiology in their classrooms without the detail of Level 3 supporting tasks and assessment.

There is a long waiting list for the limited number of places on the *Level 3 Safety in Microbiology* course. While it is useful for teachers to have undertaken this course, in most cases it is often best if the school has a technician trained to Level 3 because in practice the preparation of media, sub-culturing and safe disposal of contaminated materials will be done by technical support staff.

We are proposing to run a residential two-day course for teachers with Day 1 covering risk assessment, levels of work, the Microbiology Code of Practice, aseptic technique, sub-culturing technique, and dealing safely with spills. During this time teachers will also be made aware of the Level 3 tasks that are required of their technical support staff. The focus of Day 2 will be on microbiology in the curriculum and give teachers the opportunity to try some practical work suitable for Higher and Advanced Higher as well as some simple activities for BGE. The first running of this course will be 29-30 September 2016 and further details are available on the SSERC website - see <http://www.sserc.org.uk/index.php/cpd-sserc/cpd-courses-sserc34/4038-microbiology-for-teachers>.



# Demonstrating Frustrated Total Internal

**This is a good practical activity for Advanced Higher as FTIR has strong similarities to quantum tunnelling.**

## You will need

- Class 2 laser (not laser pointer).
- 2 semicircular glass or acrylic prisms.
- Small piece of thin paper or aluminium foil.

It will be much easier to observe the effect we are looking for if light levels are low.

Put the semicircular prism flat on the bench.

Aim the laser through the curved surface at the midpoint of the flat face. The laser beam then meets the curved surface at zero degrees to the normal and does not deviate at this boundary.

Adjust the angle of the block until total internal reflection is evident. No light is escaping from the flat face (Figure 1).

Now place a second block alongside the first as shown.

Make the blocks touch at one end but separate the other ends with a thin piece of paper or foil. This forms a very narrow wedge-shaped gap between the blocks.

At this point, it is unlikely that you will see any light transmitted in the second block.

Squeeze the blocks together.

You should now see a transmitted beam in the second block. If you place a piece of card vertically in its path, you may be able to see more clearly that more light is transmitted as you squeeze harder (Figure 2).

## Safety

- Use only a Class 2 laser. Do not use a laser pointer as there is a strong possibility that it could be more powerful than the labelling suggests.
- Do not look directly at the beam.
- Ensure that the beam is not pointing at anyone else.
- If necessary, use a beam stop.
- Watch out for stray reflections.

## Theory (and relationship to quantum tunnelling)

When total internal reflection occurs, no energy is carried by a wave across the acrylic/air boundary. However, the wave that is incident on the boundary is not simply "cut off". It exists beyond the boundary as an evanescent wave, tailing off exponentially and, as mentioned, transferring no energy (Figure 3).

If we were to bring a second piece of acrylic in perfect contact with the first there would be no internal reflection and no evanescent wave. The original wave would continue into the second prism.

Even if the second piece of acrylic does not touch the first, the evanescent wave can become a conventional travelling wave again inside this block. Energy is transferred and total internal reflection is "frustrated" (Figure 4). Because the evanescent wave tails off exponentially, the effect is only perceptible over a short distance - a few wavelengths or so. Since the wavelength of light is of the order of a few hundred nanometres, the blocks have to be no more than a couple of micrometres apart.

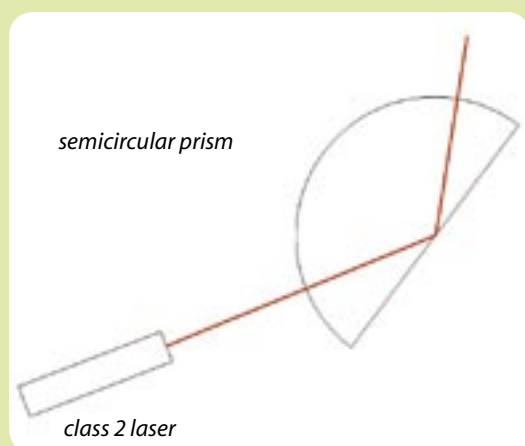


Figure 1 - Total internal reflection.

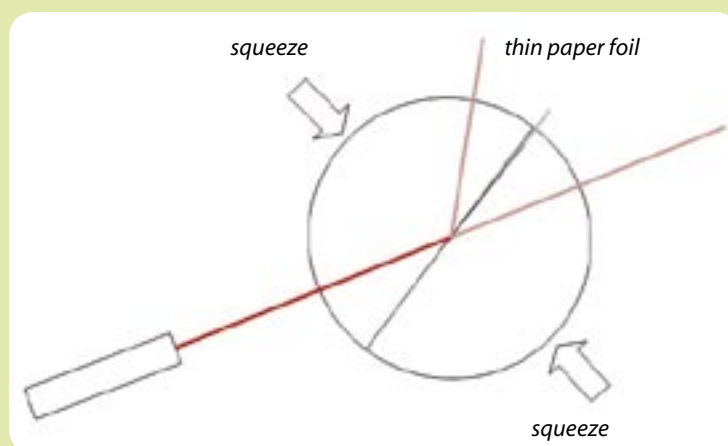


Figure 2 - Frustrated total internal reflection.

# Reflection (FTIR)

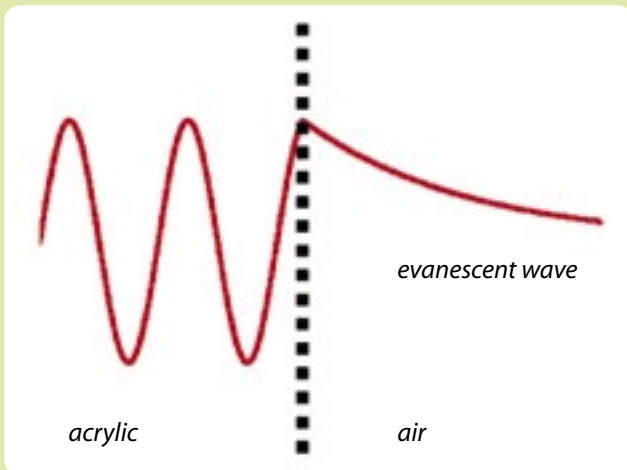


Figure 3 - Evanescent wave.

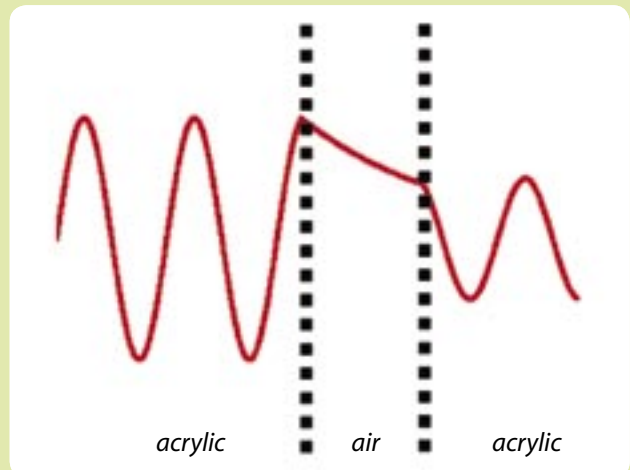


Figure 4 - Transmission across air gap.

When quantum tunnelling is discussed, the term “potential barrier” is often used and this can be a bit abstract for students. If we were dealing with an electron, a potential barrier could be insulating material that, classically speaking, the electron did not have the energy to pass through. We know that the electron has a wavefunction associated with it and that this wavefunction describes the probability of the electron being in a particular location. As with light undergoing TIR, this wavefunction does not simply become truncated when it meets a boundary that, classically, it could not cross. Instead, the electron’s wavefunction becomes evanescent at this point - it tails off exponentially. This means that there is still a probability that the electron can be found at the other side of the barrier. We say that such electrons that are found to have crossed the barrier have “quantum tunnelled” through it.

## Frustrating FTIR

This demonstration took us some time to get working. The picture (Figure 5) shows a false start - the green laser is reflected at the

boundary, but when a second block is put in place, there appears to be transmission in the direction of the original beam. However, these blocks are about 1 mm apart and separating them further does not dramatically reduce the irradiance of the onward beam. On closer examination, some light was emerging from the hypotenuse face of the prism and simply entered the second prism when it was put in place.

Sometimes, no FTIR was visible when the prisms were placed in direct contact, without the foil spacer. This seemed to be largely dependent on the types of prisms used. At times, FTIR could be seen if the blocks were subsequently squeezed together. We concluded that either the surfaces in contact were not at all smooth at the micrometre level, or that they were in some way bowed or otherwise distorted.

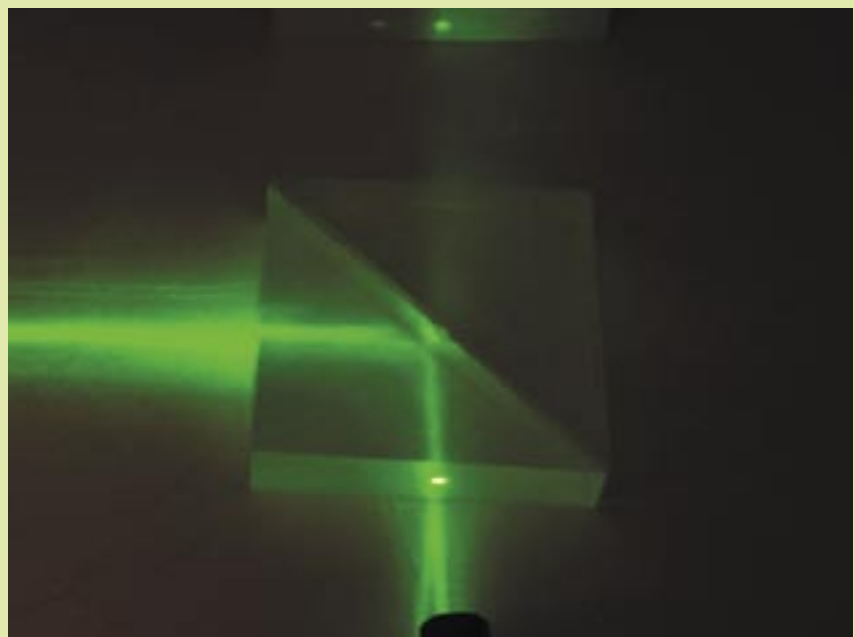


Figure 5 - Not what it first seemed.

# Treat 'em to

## Background

Clock reactions are amongst the most dramatic and visually pleasing chemical demonstrations [1].

Typically after a clock reaction has been started there is a period during which no noticeable change takes place and then a change (often in colour) occurs. This sudden and unexpected nature of the change gives clock reactions their charm and visual appeal.

The activity described here is based on the so-called iodine clock reaction. When a solution of hydrogensulfite (or bisulfite) ions ( $\text{HSO}_3^-$ ) is mixed with a solution of iodate ( $\text{IO}_3^-$ ) ions and a starch solution, the mixture remains colourless for a time and then suddenly turns blue. The clock period (the time from mixing to colour change) can be changed by varying the concentrations of the reactants. Whilst the chemistry of the iodine clock reaction is quite complex the effect of concentration on the rate can be readily shown and appreciated.

It might at first glance seem strange to have a chemistry article in the SSERC Bulletin with a title such as the one used here and so some explanation is in order. The activities which follow are based on an article of the same name by Mark Whitman which



was published in the Journal of Chemical Education [2].

**Figure 1** - Mark Whitman. (Image: <http://www.k12tlc.net/mark/mark.htm>).

In his article Whitman [2] states:

*'The beauty of the activity is that it has yet to work as predicted. Always, one or two flasks turn out of sequence, or a student spills the contents of their test tube on the floor and often the last flask doesn't turn until two minutes or so after the demonstration has been completed. It is my belief that the mistakes are the heart of the activity's success. Class discussion of what might have gone wrong reinforces students' understanding. The whole procedure requires 40 minutes, but on the next quarterly exam no area receives as many correct student responses...'*

It is possible to use this activity at a number of points across the chemistry curriculum (see Appendix 1). At its heart lies the premise that changing the concentration of one or more reactants can lead to a change in the rate of a chemical reaction.

## The reactions - oxidation of hydrogensulfite by iodate

The overall process can be represented (detail taken from [1]) by the following sequence of reactions shown in Table 1 below.

In reaction (1) hydrogensulfite ions reduce iodate ions to iodide ions and in reaction (2) these iodide ions are oxidised by iodate ions to triiodide ions. At this point the solution contains, amongst other things, triiodide and starch which

are the components of the blue starch-iodine complex whose formation co-occurs in reaction 4. However, reaction 3 is so rapid that the formation of the blue complex is prevented. Once all of the hydrogensulfite has been consumed then reaction 4 is no longer suppressed and the blue complex forms. So, the solution remains colourless whilst there is still hydrogensulfite present. Once the hydrogensulfite is gone the blue colour appears. Under the conditions detailed below the reaction time is reasonably linear with respect to water volume (see Figure 2).

## The activity

There are a number of ways in which one might set up the iodine clock reaction but we believe that the method described below offers opportunity for wide-ranging discussion about potential sources of error, opportunities for improvement etc.

## Preparation of solutions

In broad terms we adopt the solutions recommended by Whitman [2]. The following stock solutions are prepared:

- Soluble starch solution - approximately 10 g of starch in 250 cm<sup>3</sup> distilled water - warmed to dissolve.
- H<sub>2</sub>SO<sub>3</sub> solution prepared by adding 250 cm<sup>3</sup> of 0.2 mol l<sup>-1</sup> NaHSO<sub>3</sub> to 250 cm<sup>3</sup> of H<sub>2</sub>SO<sub>4</sub> (0.1 mol l<sup>-1</sup>).
- Iodic acid solution (0.038 mol l<sup>-1</sup>).

1	$\text{IO}_3^- (\text{aq}) + 3 \text{HSO}_3^- (\text{aq}) \longrightarrow \text{I}^- (\text{aq}) + 3 \text{SO}_4^{2-} (\text{aq}) + 3 \text{H}^+ (\text{aq})$
2	$\text{IO}_3^- (\text{aq}) + 8 \text{I}^- (\text{aq}) + 6 \text{H}^+ (\text{aq}) \longrightarrow 3 \text{I}_3^- (\text{aq}) + 3 \text{H}_2\text{O} (\text{aq})$
3	$\text{I}_3^- (\text{aq}) + 3 \text{HSO}_3^- (\text{aq}) + \text{H}_2\text{O} (\text{l}) \longrightarrow 3 \text{I}^- (\text{aq}) + \text{SO}_4^{2-} (\text{aq}) + 3 \text{H}^+ (\text{aq})$
4	$2 \text{I}_3^- (\text{aq}) + \text{starch} \rightleftharpoons (\text{blue starch-I}_5^- \text{ complex}) + \text{I}^- (\text{aq})$

**Table 1** - Sequence of reactions.



# Tchaikovsky!

Volume of water in flask, cm <sup>3</sup>	Reaction time, s	Volume of water in flask, cm <sup>3</sup>	Reaction time, s
125	81	145	120
130	90	150	127
135	98	155	138
140	105		

Table 2 - Typical reaction times post mixing.

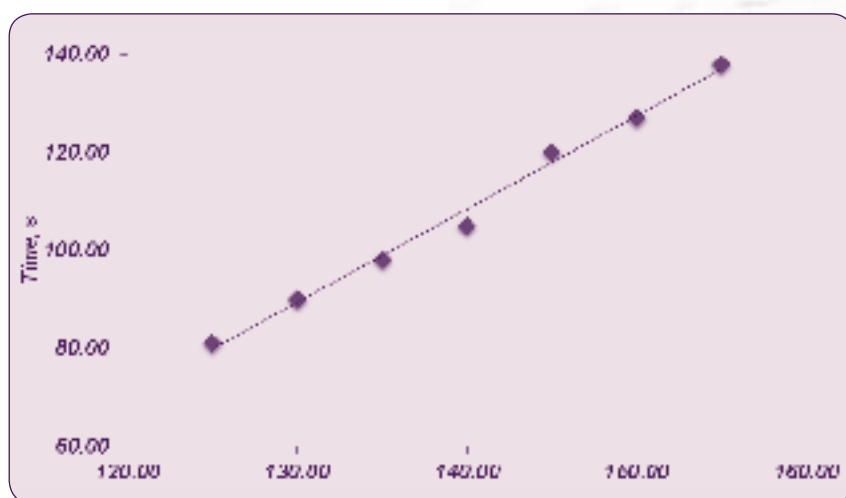


Figure 2 - Time taken, as a function of volume of water, for the appearance of the characteristic blue colour of iodine-starch complex. Experimental details in the text.

## 'Construction of the clock'

- 1) Prepare 7 conical flasks (250 cm<sup>3</sup>) containing 125, 130, 135, 140, 145, 150 and 155 cm<sup>3</sup> of distilled water. (Measuring the mass of water in the flask and assuming that 1 cm<sup>3</sup> of water has a mass of 1.0 g is probably the most accurate way of approaching this).
- 2) Prepare 7 test tubes each containing 8 cm<sup>3</sup> of the iodic acid solution.
- 3) To each conical flask add 1 cm<sup>3</sup> of soluble starch solution.
- 4) To each conical flask add 3 cm<sup>3</sup> of the H<sub>2</sub>SO<sub>3</sub> solution.
- 5) Add the iodic acid solution to the flask and measure the length of time taken for the appearance of the blue colour.

Table 2 shows typical reaction times post mixing with the data being plotted in Figure 2.

As can be seen (Figure 2), under the conditions used the reaction time is reasonably linear with respect to water volume. Typically at volumes below about 110 cm<sup>3</sup> the reaction time is non-linear. As can be seen from the data, quite modest increases in the volume of water present can have a significant impact on the time taken for the reaction to go to completion.

## So what about Tchaikovsky?



Whitman [2] acknowledges that the idea of linking the iodine clock to a musical performance was not new having its origins at by an anonymous individual at Virginia Tech.

The music of the 1812 Overture by Tchaikovsky will be familiar to most of us. A key feature of the overture itself is the series of cannons which are fired during the performance. It is possible, with careful solution preparation, and a fair wind, to arrange conditions such that the solutions in the conical flasks change as the cannons are heard in the music. The timings will of course vary with the recording of the 1812 Overture which you use. For reasons of convenience (i.e. it was the one available) we use the version conducted by Antal Doráti featuring the Minneapolis Symphony Orchestra.

We pick a point in the music some 2 minutes before its end. It is at that point that 15 volunteers are invited to mix the contents of a test tube containing iodic acid solution (8.0 cm<sup>3</sup>) into a conical flask which contains soluble starch, H<sub>2</sub>SO<sub>3</sub> solution (3 cm<sup>3</sup>) and the 'correct' volume of water as predicted/calculated from a plot such as that shown in Figure 2. The timings we 'aim for' are shown in table 3.

In our version there are about 12 cannons in the final 2 minutes of the music and we add an extra couple of flasks in the hope that at least one will 'go off' at the right time. The final solution is set to change colour as the music ends. The overall effect of 15 participants lined up willing their solutions to

Figure 3 - 'The music'!

Flask N°	Time, s	Flask N°	Time, s	Flask N°	Time, s
1	75	6	84	11	90
2	77	7	85	12	92
3	79	8	86	13	93
4	81	9	87	14	95
5	82	10	88	15	120

Table 3 - Timings.

change in time with the cannons can be exciting and memorable. One teacher several years ago said to us 'I shall never listen to that music again without that image coming into my mind!'

We agree with Whitman [2] that '....it has yet to work as predicted.' We have on one occasion had as many as 11 solutions change at exactly the correct moment in time but a full

set is yet to be accomplished (now there's a challenge...). Discussion as to why not all solutions 'behave' can lead to the identification of a number of possible reasons including (but not limited to):

- Incorrect mixing technique.
- Temperature effects – participants should be encouraged to hold their flasks at the top to avoid warming the solution.

- Incorrect measurement of solutions – have all volumes of water been measured using the same glassware/balance etc?
- Is all the iodic acid transferred from the test tube?
- Are the iodic acid and H<sub>2</sub>SO<sub>3</sub> stock solutions stable?

In our experience the first 2 items on the above list are the ones most likely to cause problems. ◀

#### References

- [1] Shakhshiri, B.Z. (1992), Clock Reactions in Chemical Demonstrations: A Handbook for Teachers of Chemistry Volume 4, pp 3-89, University of Wisconsin Press, Madison.
- [2] Whitman, M. (1983), Treat 'Em to Tchaikovsky. J. Chem. Educ., 60, 229.

#### Suppliers of materials

We have used the following sources for our reagents but others could be used:

- Soluble starch from Scientific and Chemical (product code ST015).
- Sodium bisulfite (NaHSO<sub>3</sub>) from Sigma-Aldrich (marketed as an ACS reagent mixture of NaHSO<sub>3</sub> and Na<sub>2</sub>S<sub>2</sub>O<sub>5</sub>; product code 243973).
- Iodic acid (HIO<sub>3</sub>) from Sigma-Aldrich (product code 58060).
- Sulfuric acid from Scientific and Chemical (product code SU045/1).

#### Health and safety considerations

- 1) A risk assessment should be carried out particularly in respect of stock solution preparation.
- 2) The H<sub>2</sub>SO<sub>3</sub> solution is sufficiently dilute so as to not merit any warning labels; however, those suffering from asthma should avoid breathing in the vapour.

#### APPENDIX 1 Additional information

##### Curriculum links

##### 1) CfE

##### Chemical change

Through experimentation, I can identify indicators of chemical reactions having occurred. I can describe ways of controlling the rate of reactions and can relate my findings to the world around me - SCN 3-19a.

I can collect and analyse experimental data on chemical reactions that result in an obvious change in energy. I can apply my findings to explain the significance of the energy changes associated with chemical reactions - SCN 4-19a.

##### 2) NATIONAL 3

##### Key Area – Rates of reaction

There are 4 factors that affect the rate of reaction: temperature, concentration, catalyst and surface area. Increasing the temperature, concentration and surface area will speed up a reaction, decreasing them slows reactions down.

##### 3) NATIONAL 4

##### Key Area – Rates of reaction

Reactions monitored and graphs interpreted.

A working knowledge of the factors affecting rates of reaction is required for this Course. To compare rates of chemical reactions, changes in mass, volume and other quantities can be measured. Graphs can then be drawn to help this comparison.

##### 4) HIGHER

##### Key Area – Controlling the rate

Learners can investigate the effect of temperature by using the reaction between sodium thiosulfate and acid in which a sulfur precipitate forms, or the reaction of potassium iodate and bisulfite/starch solution.

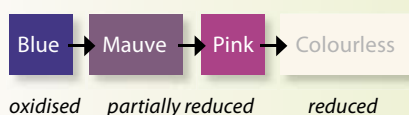
##### Key Area – Getting the most from reactants

Chemical 'egg race' activities can be used to provide opportunities to practise or consolidate the mathematical skills being developed. In the Chemical Egg Timer, teams are given a graph showing how the concentration of potassium iodide affects the time taken for the blue-black colour to appear in a hydrogen peroxide/iodide clock reaction.

# Quantifying respiration rate using resazurin

Within the biology curriculum, at National 5 and Higher [1], it is suggested that learners might use the colour changes of resazurin dye as a measure of respiration rate, or dehydrogenase activity, in yeast.

Resazurin dye, sometimes known, as *Alamar Blue™*, was first used to quantify the bacterial content of milk and is now also used as an indicator of cell viability in mammalian cell cultures. Because resazurin changes colour when it is reduced, it will change colour in the presence of respiring cells. The oxidation of respiratory substrates such as glucose, catalysed by dehydrogenase enzymes, produces hydrogen ions which in cells will normally transfer to and reduce co-enzymes such as NAD. If resazurin is present in the surrounding medium it will also be reduced by hydrogen and undergo the following colour changes:



Various protocols using resazurin to illustrate dehydrogenase (or respiratory) activity in yeast have been available for some time [2]. Based on these, and in response to requests from teachers for data sets that can be easily accessed by students, the Biology Team at SSERC has considered two ways of using resazurin and yeast cultures to generate quantifiable data. Here we outline these protocols briefly; more technical detail of the methods, suggestions for investigations and additional data sets can be found on the SSERC website [3].

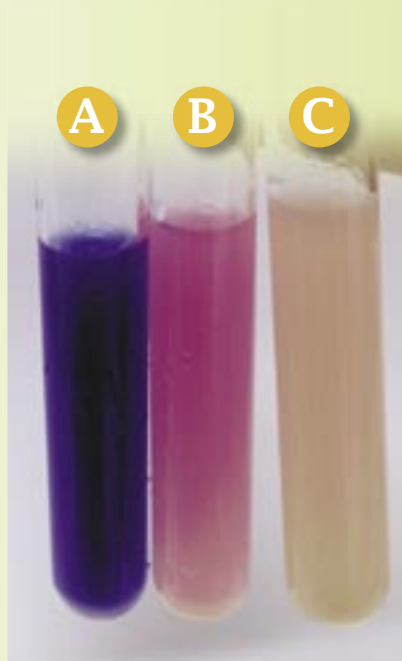


Figure 1

- Test tube B - 3 cm<sup>3</sup> 2.5% yeast suspension, 3 cm<sup>3</sup> 5% glucose solution, 3 cm<sup>3</sup> 0.01% resazurin.
- Test tube C - 3 cm<sup>3</sup> 2.5% yeast suspension, 3 cm<sup>3</sup> 5% glucose solution, 3 cm<sup>3</sup> distilled water.

Figure 1 shows the colour changes after incubation for 20 minutes at 35°C.

Test tubes containing 3 cm<sup>3</sup> 2.5% yeast suspension, 3 cm<sup>3</sup> 5% glucose solution and 3 cm<sup>3</sup> 0.01% resazurin, were incubated at 35°C and colour changes were recorded every 3 minutes over a period of 30 minutes and used to produce a colour chart (Figure 2). Resazurin dye will change colour, as indicated from left to right in the chart, as it becomes increasingly reduced. The numerical values can be related to respiratory/dehydrogenase activity in yeast with 10 being equivalent to no activity.

Further investigations were set up in which yeast concentration, glucose concentration and temperature were varied. ▶

## 1) Using resazurin and a colour chart to investigate respiration rate in yeast

As a starting point we set up the following:

- Test tube A - 3 cm<sup>3</sup> boiled 2.5% yeast suspension, 3 cm<sup>3</sup> 5% glucose solution, 3 cm<sup>3</sup> 0.01% resazurin.



Figure 2 - Resazurin reduction colour chart.

A typical set of results using 2.5% yeast suspension, 5% glucose solution and 0.01% resazurin is shown in Figure 3.

Using this basic method, students might carry out investigations into respiratory rate in yeast by altering variables such as temperature, respiratory substrate, substrate concentration, type of yeast and yeast concentration.

## 2) Using resazurin and a colorimeter to investigate respiration rate in immobilised yeast

The turbidity of yeast suspensions makes it impossible to obtain reliable colorimeter readings for the decolourisation of resazurin. Immobilisation of the yeast in gel beads means that the yeast can easily be separated from the surrounding solution at various points over time and colorimeter readings can be taken. By setting the colorimeter filter at 590 nm (measuring the disappearance of the resazurin's blue colour) data corresponding to the respiratory activity of the yeast can be generated.

Again students could carry out investigations into respiratory rate in yeast by altering variables such as temperature, respiratory substrate, type of yeast and yeast concentration. A typical set of results using 5% glucose solution, 0.01% resazurin and varying concentrations of yeast suspension is shown in Figure 4.

A protocol detailing the methods for carrying out the basic practical activities discussed here, together with additional data sets and the colour chart, can be found on the SSERC website (3).

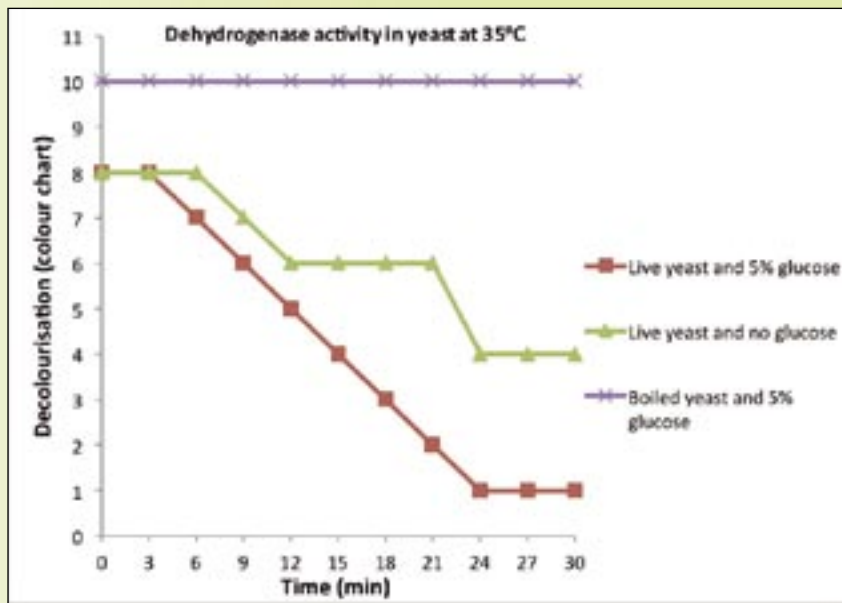


Figure 3 - Dehydrogenase activity in yeast at 35°C.

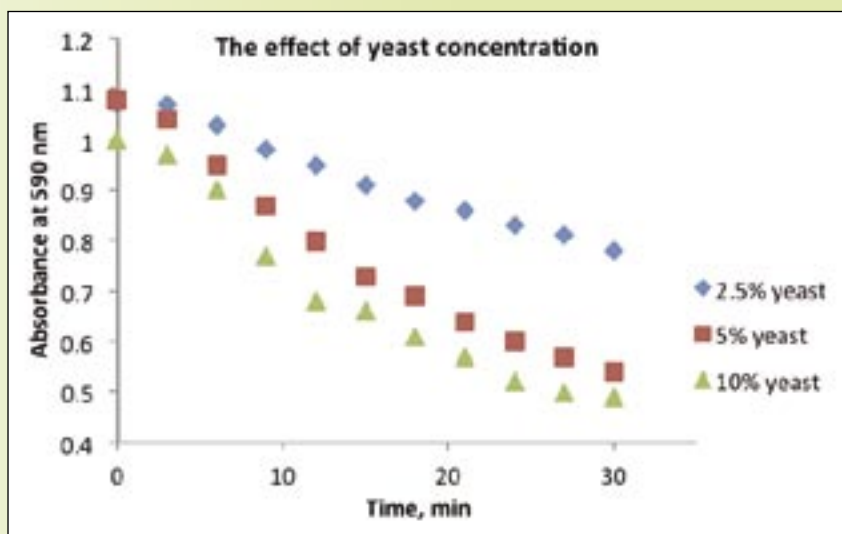


Figure 4 - The effect of yeast concentration.

### References

- [1] National 5, Higher Biology and Higher Human Biology Support Notes:
  - [http://www.sqa.org.uk/files\\_ccc/CfE\\_CourseUnitSupportNotes\\_N5\\_Sciences\\_Biology.pdf](http://www.sqa.org.uk/files_ccc/CfE_CourseUnitSupportNotes_N5_Sciences_Biology.pdf).
  - [http://www.sqa.org.uk/files\\_ccc/CfE\\_CourseUnitSupportNotes\\_Higher\\_Sciences\\_Biology.pdf](http://www.sqa.org.uk/files_ccc/CfE_CourseUnitSupportNotes_Higher_Sciences_Biology.pdf).
  - [http://www.sqa.org.uk/sqa/controller?p\\_service=Front.search&pContentID=41454&q=Higher%20Human%20Biology](http://www.sqa.org.uk/sqa/controller?p_service=Front.search&pContentID=41454&q=Higher%20Human%20Biology).
- [2] For example, the Higher Biotechnology Protocols Booklet can be accessed at: [http://www.educationscotland.gov.uk/resources/nq/b/nqresource\\_tcm4339534.asp?strReferringChannel=educationscotland&strReferringPageID=tcm:4-615801-64&class=l1+d86716](http://www.educationscotland.gov.uk/resources/nq/b/nqresource_tcm4339534.asp?strReferringChannel=educationscotland&strReferringPageID=tcm:4-615801-64&class=l1+d86716).
- [3] See <http://www.sserc.org.uk/index.php/biology-2/biology-resources/higher-human-biology-res/human-cells-h/3767-cellular-respiration?highlight=WyJyZXNhenVyaW4iXQ==SSERC> for protocol and data sets.

# Evidence Based Education

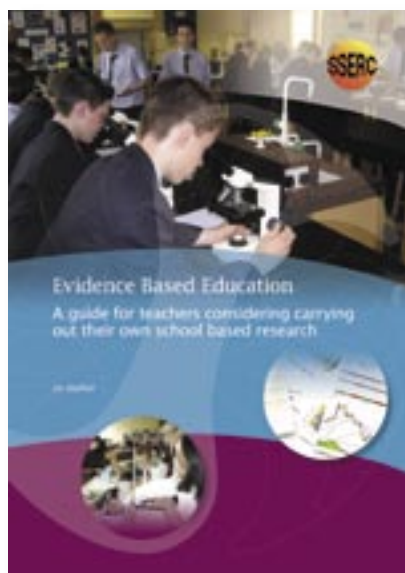
**Decision making in education should be based on sound research evidence and should be the concern of every teacher. This new publication written by Jim Stafford describes the main methods for collecting evidence on which to base decisions.**

Learning how research works is important so that teachers become research literate enabling them both to carry out their own research into what is effective and to be critical consumers of the research findings of others. Educational initiatives that are not supported by evidence should be challenged and the research that is required to demonstrate their effectiveness should be identified.

This document provides advice on designing your own research and analysing results. The challenges of getting evidence based practice accepted to become part of everyday practice in education are considered.

In his foreword to Evidence Based Education, Ken Muir (Chief Executive of The General Teaching Council for Scotland) makes the following observation:

*Evidence Based Education ...reminds us that all education research should have a purpose and provide evidence for teachers taking decisions that will lead to improvement in practice and/or outcomes for learners.*



Printed copies of Evidence Based Education will be sent to all secondary schools early in the new school year. In the meantime copies can be downloaded from the SSERC website at [http://www.sserc.org.uk/images/Leadership/EBE\\_1/EBE%20book%20web2.pdf](http://www.sserc.org.uk/images/Leadership/EBE_1/EBE%20book%20web2.pdf).

## Technician survey

In 2005 a national survey (*SEED Project: CPD and Related Activities for Technical Support Staff: National Survey Report 2005*) was carried out to assess the position and the variety of extant support arrangements within Scottish local authorities [1].

The introduction of *Curriculum for Excellence* has seen an increase in the demand for practical work in schools and within SSERC we are planning for a new national survey to gather data on the provision of technical and other support for school science and technology in both primary and secondary schools to determine the current position nationally. A questionnaire will be sent to key personnel in all Local Authorities. In addition, we will be seeking the views of technicians. When the survey is available we will create links on our website – keep an eye on <http://www.sserc.org.uk> or <http://www.sserc.org.uk/index.php/technicians>.

### Reference

- [1] Copies of the survey can be downloaded at <http://www.sserc.org.uk/index.php/technicians/national-survey-2005>.

# Go on tweet, it's good for you!

Using Twitter as a departmental information tool can offer lots of benefits to Technology teachers, whole departments and their pupils. Here we analyse five of those benefits and how they can help you at school.

## 1) Networking with other schools across the country

There are now an increasing number of schools from both the local authority and independent sector with their own department Twitter pages. Follow their pages and take the opportunity to build partnership links. It is amazing how posts from other schools can inspire your own work and lead to collegiate discussion.

## 2) Information for parents/guardians

Twitter is an effective method of communication with parents who also possess accounts. Communicate deadlines for class work, department showcase event details or even supported study/homework information. Building parental support and involvement in the department and utilising this different method of information sharing can be extremely rewarding.

## 3) Showcase your pupils' work

If your pupils create great folios, models or CAD work, show it off (but don't publish live exam material or assessment work!) Moving on from the days where good work was pinned on the classroom wall, pupils receive a massive boost in self-confidence when their efforts are featured in a picture posted online.

Before you post a photo of a pupil you must check for any permission required and it is advisable to agree a policy with your Head Teacher. Some schools post photos with pupils, some schools do not. Be aware of your school/local authority policy and ensure you adhere to it.

## 4) Find out information from other educational organisations

School or STEM competitions, CPD events, machine and equipment details and even curriculum updates are all posted regularly on Twitter by various educational organisations. If knowledge is power then prepare to be fully energised! (And check out our Twitter page @SSERCtechnology.)

## 5) Teach safe online posting to your pupils

Some department accounts are posted on only by staff, but there are others where a staff and pupil working group or extracurricular STEM club participate in what is posted. Showing pupils how to tweet positive messages about something they are passionate about, and how to avoid negative social media pit falls or trolling is an essential lesson in the modern classroom and digital age.

Here are just a few of the active Scottish Technical department Twitter pages who use the medium effectively.



## For your eyes only

**One of the most frequent requests for guidance that we receive is for information on protective eyewear. Here we breakdown the information from BS 4163:2014 to help you make the right choice in the workshop.**

In BS 4163:2014 'Health and safety for design and technology in education and similar establishments - Code of Practice' there are five different levels of PPE protective eyewear directly referred to for use in Scottish Technical departments. Welding has its own classification and two of the five levels detailed are for Soft Soldering and Ferric Chloride Etching respectively and will be covered in a later bulletin article. The three levels of eye protection PPE guidance which are relevant to practical work in Scottish craft rooms are:

### BS EN 166:2002 1F low energy impact glasses

The 'F' refers to the mechanical strength, and low energy impact protective eyewear have been tested to resist a 0.86 g steel ball fired at 6 mm thick glasses at 42 ms<sup>-1</sup> [1]. This is the minimum standard



of safety glasses that are approved for selected use in a school workshop. However, there are common workshop machines and tool activities where these glasses are not appropriate for use.

These standard of safety glasses are recommended for use with Hand Tool use, Cutting units, Sawing machines, power Hacksaws and metal cutting Bandsaws [2].

### BS EN 166:2002 1B medium energy impact goggles

The '1' is the optical quality of the ocular (and 1 is the highest quality available) [3]. The 'B' refers to the resisting of high speed particles, and medium energy impact is tested by firing a 0.86 g steel ball at 120 ms<sup>-1</sup> at 6 mm thick goggles [4]. The use of this level of safety goggles will ensure you meet all recommendations for eyewear PPE in a Scottish Technical department (excluding the 3 specific tasks detailed within the face shield spec).



These safety goggles are specifically approved for Abrasive Belt/Linishing machines, Surface Grinding machines, Grinders, Drilling machines, all portable Tool use, Centre Lathe, Wood Lathe [5] and the majority of other workshop tool and machine tasks.

### BS EN 166:2002 1 9B face shield

The '9' refers to ocular resistance to molten metals and hot solids on a faceshield [6]. Again the 'B' refers to resisting high speed particles and medium energy impact. These are the only grade of face shield that are acceptable for use during hot metal work.



The faceshield is the only grade of eye protection PPE recommended for Forging, Casting and can also be worn for all Lathe work to protect the full face of the user. ◀

**Ensuring the correct level of eye protection PPE being worn in the craft room is essential in contributing to best and current safe practice being applied in a department. Signage should also be displayed to guide users as to which eye protection should be worn for the different tasks. These specific details can then be placed in the department Health and Safety policy and/or pupils' tool and machine passport.**

#### References

- [1] <http://www.abdo.org.uk/wp-content/uploads/2013/04/ABDO-Protective-Eyewear-WEB.pdf>.
- [2] BS 4163:2014 The British Standards Institution.
- [3] <http://www.hse.gov.uk/foi/internalops/oms/2009/03/om200903app3.pdf>.
- [4] <http://www.abdo.org.uk/wp-content/uploads/2013/04/ABDO-Protective-Eyewear-WEB.pdf>.
- [5] BS 4163:2014 The British Standards Institution.
- [6] <http://www.abdo.org.uk/wp-content/uploads/2013/04/ABDO-Protective-Eyewear-WEB.pdf>.

## Air weapons in schools

**A forthcoming change in the law will affect any school whose physics department owns an air rifle. Section 2 of the Air Weapon and Licensing (Scotland) Act 2015, which comes into effect on December 31<sup>st</sup> 2016, makes it an offence for a person to use, possess, purchase or acquire an air weapon without holding a certificate.**



*Image: thebarrowboy (AJB Photography) at www.flickr.com.*

### **Schedule 1 of The Act provides exemptions to this.**

#### **The law states:**

- 1) It is not an offence under section 2(1) for an individual ("A") to:
  - (a) borrow an air weapon from the occupier of private land, and
  - (b) use and possess the weapon on that land, without holding an air weapon certificate, if the conditions in sub-paragraph (2) are complied with.

The conditions are:

- (a) A uses and possesses the air weapon under the supervision of the occupier of the land or an employee or agent of the occupier ("the supervisor"),
- (b) the supervisor holds an air weapon certificate,
- (c) A complies with any conditions attached to the supervisor's certificate so far as relevant to the use and possession of the air weapon by A, and
- (d) where A is under the age of 14, the supervisor is aged 21 years or more.

In a school situation, this means that someone should hold an air weapon certificate for the rifle. It would make sense for this to be a member of the physics department. This person should always supervise its use. At the time of writing, we believe that the cost of a license is likely to be around £72 for a 5 year permit. The license is not transferrable- if the holder moves to a new school, a new license will be required. In order to assist Police Scotland administration processes, certificates that are issued as a result of applications received between the 1 of July 2016 and the 31<sup>st</sup> of December 2016 will last between 18 and 26 months. The cost of the certificate applied for during this period will be pro rata based on £72. Certificates issued as a result of applications received after the 31<sup>st</sup> of December 2016 will last for the full 5 years. You can find out more here - <http://airweapon.scot/how-to-apply>.

If you have an air rifle and no longer want to keep it, you can hand it in to a police station. Instructions for the safe (and ethical) use of an air rifle in class can be found in SSERC Bulletin 190. ◀