SSERC Bulletin

Ideas and inspiration supporting science and technology for all Local Authorities

No. 261 - Winter 2017

©SSERC 2017 - ISSN 1759-1082

Time to revisit the Schools Chips?

Figure 1 is a picture from SSERC Bulletin 175 which was published towards the end of 1992. It shows four Schools Chips. This was a major project at the time, designed to address the lack of teaching materials for microelectronics. Four types of chip were created, each with a window on top through which the layout of its innards could be seen.

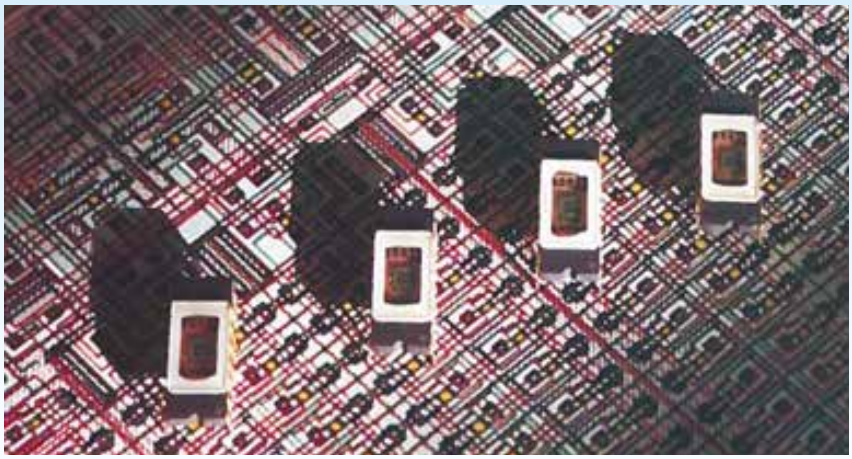


Figure 1 *- Four Schools Chips.*

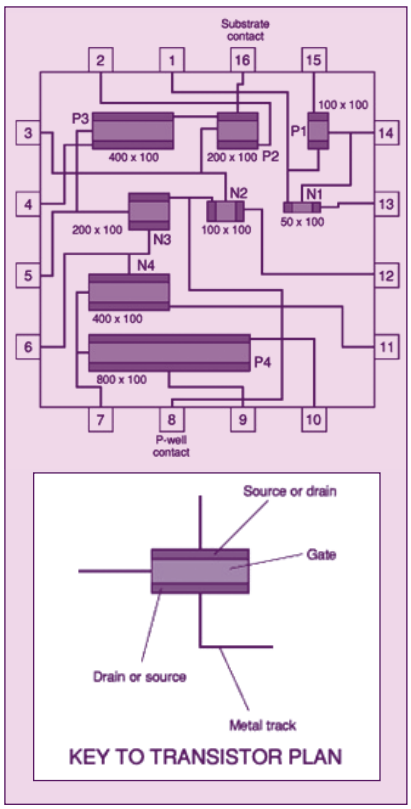


Figure 2 *- Layout of Chip 2.*

A fair number of investigations could be carried out with the chips but we suspect that few ever were, at least initially. The chips had to be mounted on breadboards and connections made through short pieces of wire and crocodile clips. Setting up circuits was fiddly and time consuming. A diagram of Chip 2 is shown in Figure 2.

Physics teacher Alex Munro, who runs JJM Electronics, came to the rescue with some socketed boards for the chips, complete with overlays (Figure 3). These boards are still available, though the chips are becoming harder to find. There is, however, a good chance that many schools have stocks. Given that there are a number of relevant core practicals and some innovative investigation work that can be done with the chips, it is worth having another look at them. An example is shown below.

Chip 1 can be used to investigate the Hall Effect. This phenomenon is mentioned in the current (2017/18) Higher Physics Support Notes. It could also form part of an Advanced Higher Investigation.

If there is a flow of electrons through a material and a magnetic field is applied at right angles to the direction of flow, there will be a force on the electrons as shown in Figure 4.

There will be a depletion of electrons on one side of the conductor and an excess on the other. This means there will be a potential difference across the conductor, at right angles to both the electron flow and the magnetic field. This potential difference is known as the Hall voltage.

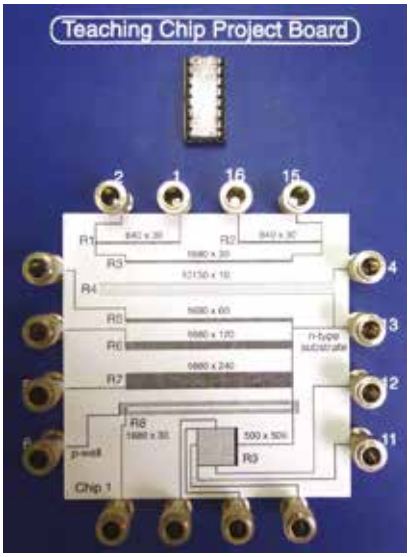


Figure 3 *- Chip in a board.*

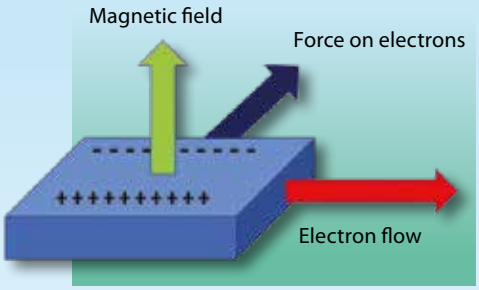


Figure 4 *- The Hall Effect.*

The circuit shown in Figure 5 can be used with Chip 1 to investigate the Hall Effect.

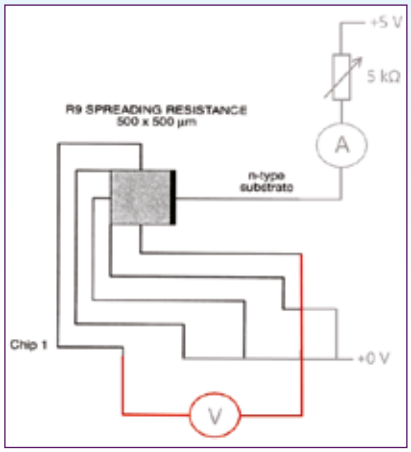


Figure 5 *- Hall Effect circuit.*

- Pins 9, 10 and 11 are connected to 0 V.
- Pin 13 is connected via an ammeter and variable resistor to + 5 V. This allows you to vary the current in a square slab of doped silicon.
- Pins 8 and 12 are connected to a voltmeter. This allows you to measure the p.d. across the silicon - the Hall voltage.

The relationship between the Hall voltage and current can be studied for different magnets placed on top of the chip. Note that we got a small Hall voltage that varied linearly with current even with no magnet in place. We are still investigating this. It does not appear to be due to the earth's magnetic field.

Other chips, other investigations

There are four chips in the set as shown in Table 1.

Notes

As mentioned, all chips have a "window" through which individual structures may be seen (Figure 6). With the advent of USB and smartphone microscopes, this feature may have come of age.

Figure 6 *- Chip, showing "window".*

The chips present opportunities for Advanced Higher investigative work, and perhaps also experiments for the new Assignments.

Chip	Name	Notes and possible investigations
1	**Resistor Chip**	See SSERC Bulletin 175. R1, 2 and 3 are the same width but different lengths. R5, 6 and 7 are the same length but different widths. R4 is a metal resistor. R9 is used for the Hall Effect demonstration and investigations. R8 is an n-type resistor whereas the others, except for R4, are p-type. The relationships between length/ width and resistance can be studied. Polarity is important for some resistors.
2	**MOSFET Chip**	See SSERC Bulletin 189. Contains four n-channel and four p-channel transistors with different aspect ratios. Under the current curriculum, the above investigation on the variation of drain current with gate voltage is the one most likely to be of relevance to schools.
3	**Optoelectronics Chip**	See SSERC Bulletins 172 and 193. Contains 13 p-n junctions, 10 of which are light sensitive. A variety of lengths and widths are incorporated. Once linearity of response has been demonstrated, the inverse square law can be investigated.
4	**Ring Oscillator Chip**	Very little teaching materials seems to have been developed for this chip. There is the possibility of using it to investigate RC time constants at Advanced Higher.

Table 1 *- Four chips in the set.*

DIY molecular models

Until recently it has been completely impossible to 'see' a molecule. Realistically speaking, it still is - for most people, most of the time. So, in order to try to visualise what is happening, we need to use models. Models give us the best and most direct view of the molecular world. Modelling is also an excellent tool for learning about chemical theory, be it atomic structure, Lewis acids/bases or conjugated systems.

Figure 1 *- A 'mole' of water.*

Most modelling is nowadays carried out on computers using software to create virtual images. The professional versions of these are expensive but there are various free, open source versions that are more than good enough for school use such as Chemsketch or JMol.

There is still much to be said, however, for using 'real world' molecular models, especially with younger students: the physical interaction with the models helps to cement understanding.

It is possibly to buy molecular model sets quite easily and, on an individual basis these are not too expensive but when it comes to a class set, things become more difficult to afford - particularly these days. There are, however, cheap yet effective alternatives: one of these is to use plasticine.

The 'atoms' can be simply created by rolling balls of plasticine - the variety of colours can be used to represent different types of atoms just as in 'real' molecular modelling kits. Plasticine has the advantage of being slightly tacky to the touch so the 'atoms' will stick together without the need for any reinforcement. If this is required (for larger structures perhaps) then cocktail sticks make excellent 'bonds'. Students can thus easily make their own models and assemble/disassemble them to enhance their understanding.

Figure 2 *- Molar mass.*

Here are a few simple modelling activities that can be used to assist the teaching of otherwise dry, theoretical concepts.

Key

Hydrogen = White
Carbon = Black
Oxygen = Red/pink

The mole concept

The idea of the mole is absolutely central to chemistry but it can be a little hard for younger students to grasp.

Students make 2 sets of 4 (or 6 or 8) models of H_2O molecules (or any other simple molecule). You simply need to choose what number is going to stand in for Avogadro's number.

This set of 4 molecular models represents a mole.

This will help students have a visual aid and also be able to count the number of pieces to answer related questions, such as:

(i) how many molecules of H_2O are there in 1, 1.5, or 2 moles of H_2O?
(ii) how many moles of H_2O are there if you have 6, 7, or 8 molecules of H_2O?
(iii) how many atoms of hydrogen are there in 0.5, 1, or 2 moles of H_2O?

Methane and oxygen.

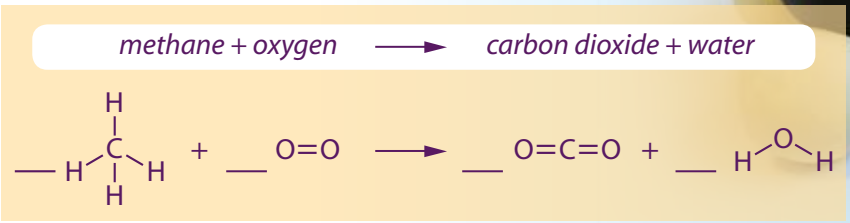


Figure 3 *- The unbalanced chemical equation and the structural formulae.*

Molar mass

The mass of a set of 4 molecules (1 mole) is measured. This represents the molar mass of the chemical substance. This does require making 'atoms' of a fairly consistent mass - a minor pain but not beyond reasonable achievability.

It is going to be difficult to get your 'molecules' exactly the right mass. The best option is to ensure they are **slightly** over the target weight and instruct the students to ignore anything after the decimal point (ideally mask the digits after the point with tape as shown in Figure 2).

Then a different number of 4-packed or any combination of 4-packed and individual molecular models, are weighed and tabulated.

It should soon become clear that a certain mass of a substance equals a set number of moles and vice-versa. Once the students seem happy with that idea then it should be relatively straightforward to explain that in 'real life' we simply replace 4 (or 6 or whatever your 'mole number' was) with Avogadro's number.

Balancing chemical equations

To help students to conceptualize the basic principles of balancing chemical equations a simple unbalanced chemical equation such as shown in Figure 3 is used. To help students, you may want to include the structural formulae as well.

Each group of students makes CH_4 and O_2 models.

Students start with only 1 model of CH_4 and 1 of O_2 to make models of CO_2 and H_2O.

After 2 H_2O molecular models are constructed using parts from the CH_4 and O_2 models, students realize that there are not enough oxygen atoms to make the CO_2 model. (or they construct the CO_2 molecule and have none left for the H_2O).

At this point, they are allowed to use another O_2 model as long as they record the number of each model they use in a table such as the one below. With the 1 carbon atom left and the 2nd O_2 model they are able to make a model of CO_2.

1 x CH_4 and 1 x O_2

Disassembled

2 x H_2O with 1 x C left over

Add more O_2

The products 2 x H_2O and 1 x CO_2

The reaction $CH_4 + 2O_2 = CO_2 + 2H_2O$

Figure 4 *- Reactants and products.*

Number of reactants and products

Now, the students should be able to balance the chemical equation by writing the number of each model used or made in front of its corresponding molecule in the unbalanced equation:

To enforce the balancing concept, students can place 1 model of CH_4 and 2 models of O_2 on one side of their desk or work bench and 1 model of CO_2 and 2 models of H_2O on the other side and count number of coloured pieces on each. They should have the same number of black, white, and red/pink pieces on both sides (Figure 4).

Limiting reactant concept

The molecular models can be used to demonstrate limiting reactant concept. The approach is very similar to balancing equations. Students are given a certain number of each type of reactant molecule and are asked to make the products. Soon they will realize that there will be some leftover of one of the reactants.

As happened in the example above - in the initial conditions, there is not enough oxygen so therefore the oxygen is the limiting factor.

Conservation of mass

To emphasize the importance of balancing chemical equations and demonstrating the law of conservation of mass, students measure the mass of 1 model of CH_4 along with 1 O_2, and 1 molecular model of CO_2 and 1 H_2O together.

The sensible thing is to weigh their CO_2 and H_2O products first and then dismantle them to re-form the CH_4 and O_2 which they weigh again. (That avoids the possibility of different 'molecules' not weighing the same).

Next, they weigh CH_4 and O_2 together and CO_2 and H_2O together.

Finally, they weigh the correct number of each model as indicated in the balanced chemical equation and not that this time, with a balanced equation, the mass is the same for both sides of the equation.

Students can repeat these procedures using other unbalanced chemical equations.

Isomers

It is quite simple to use models like this to illustrate isomerism.

Geometrical isomers - It is easy to show that a single bond allows for easy rotation around it so the arrangement of the atoms around the (black) carbon atom makes no difference.

But a double bond shows that it is impossible (unless students get silly!) to rotate between the cis and trans forms as shown below (Figure 5).

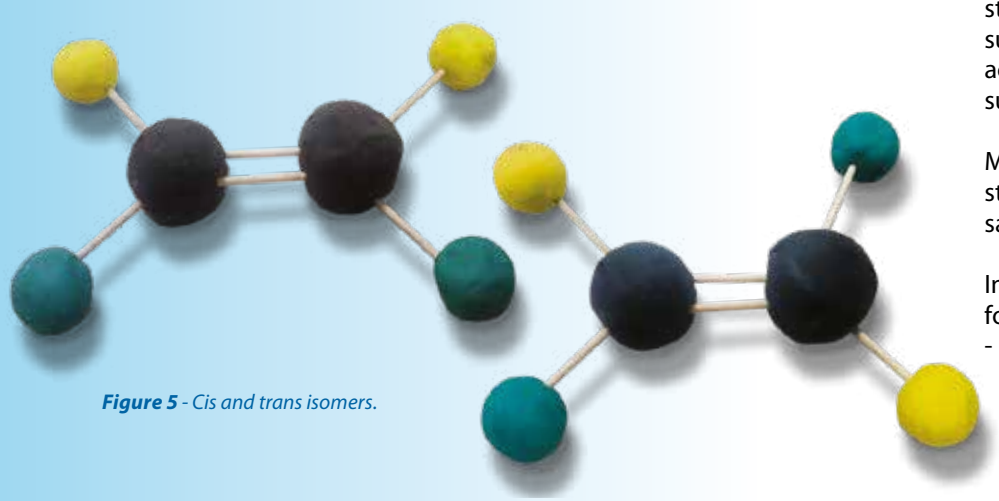


Figure 5 *- Cis and trans isomers.*

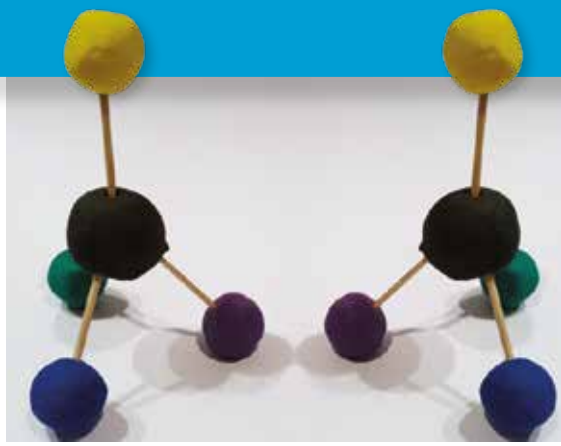


Figure 6 *- Stereoisomerism.*

You can also use your molecular models to illustrate stereoisomerism and the idea that mirror images are non-superimposable.

If you have enough colours, it is possible to create a chiral molecule with 4 different groups and the students will be able to see that if they make 2 molecules that are mirror images of each other then they cannot superimpose them one on the other.

You could then redefine the coloured balls to represent functional groups of a genuine chemical with stereoisomers.

For instance, using the same balls above, you can represent lactic acid if:
Black = a carbon atom
Yellow = a hydrogen atom
Blue = a carboxyl group
Purple = a hydroxyl group
Green = a methyl group

Edible alternatives

Similar models can be made using 'midget gem' sweets. These won't adhere to each other easily but cocktail sticks work well. There is here the added advantage that students can be allowed to eat any successful equations (as long as this activity is undertaken is suitable surroundings i.e. not in a lab).

Marshmallows and cocktail sticks can be used to make very satisfactory ionic lattices.

In fact there are endless possibilities for you and your classes to explore - happy modelling!

Wizard Genes re-visited

Delegates have recently reported difficulties in sourcing dyes to run the SSERC "Wizard Genes" experiment, published in 2007 [1] and updated in 2011 [2]. With the general trend in replacing synthetic food dyes with more natural alternatives, most commercially available food colourings simply do not electrophorese in the same way as was the case previously.

Figure 1 *- 4 different green dye mixtures following electrophoresis in a 2% agar and 1 x TBE gel and buffer.*

Figure 2 *- 4 different green dye mixtures following electrophoresis in a 2% agar and 10 mM sodium hydrogencarbonate gel and buffer.*

For instance, whilst black food colourings used to be a mixture of 3 or 4 differently coloured dyes, most food dyes now only contain "vegetable carbon" which is too large to pass though agar gel and becomes "stuck" in the well during electrophoresis. Similarly, green colourings which were formerly a mixture of blue and yellow artificial dyes are typically now made from a *Spirulina* concentrate.

Never to shy away from a challenge, our technicians were dispatched to supermarkets to assess food colourings from 3 major supermarkets, and these were tested alongside commercially available dyes from Timstar, and Scientific and Chemical.

Mindful of the need to ensure gels were robust but would run fully in a period of 40 minutes, we tested all dyes in 2% agar gel. For the purposes of demonstrating this experiment, NCBE (http://www.ncbe.reading.ac.uk/) gel tanks and 36 V transformer systems (with carbon electrode material)

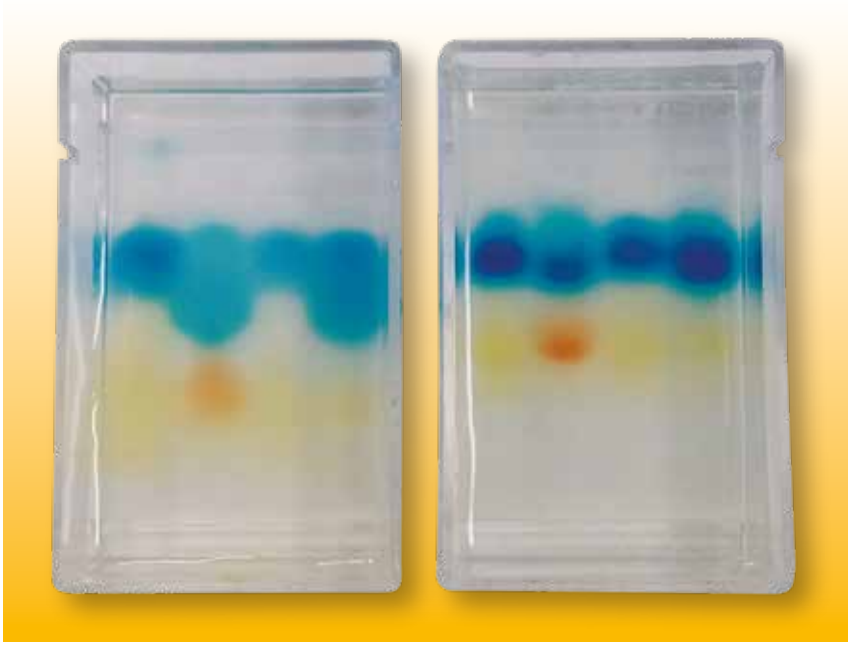


Figure 3 *- The original "Wizard Gene" mixtures. On the left the samples have been run without buffer in just tap water (2% agar gel in water). The gel on the right uses a 10 mM sodium hydrogencarbonate solution as a buffer (2% agar gel in 10 mM sodium hydrogencarbonate).*

Tube label	Food dyes present
1	60 g sucrose + 0.27 g Quinoline Yellow (E104) + 0.067 g Green S (E142) made up to 100 cm^3 with water.
2	60 g sucrose + 0.1 g Brilliant Blue (E133) + 0.133 g Quinoline Yellow (E104) + 0.033 g Allura Red (E129) made up to 100 cm^3 with water.
3	60 g sucrose + 0.213 g Quinoline Yellow (E104) + 0.053 g Green S (E142) + 0.1 g Carmiosine (E122) made up to 100 cm^3 with water.
4	60 g sucrose + 0.1 g Brilliant Blue (E133) + 0.1 g Brilliant Blue (E133) + 0.133 g Quinoline Yellow (E104) + 0.033 g Green S (E142) made up to 100 cm^3 with water.

***Table 1** - Recipes to produce 100 cm^3 of each "wizard blood" sample (each group requires 0.5 cm^3 of each of the 4 samples in separate labelled tubes).*

were used. Liquid and gel food colourings were prepared by adding 2 cm^3 of the colour to a pre-prepared tube containing 2 cm^3 of a 3:2 ratio of water:glycerol (to allow the sample to sink into the well). Solid colourings were prepared by adding 0.1 g of dye to 2 cm^3 of a 3:2 ratio of water: glycerol. Wells were loaded with 20 µL of each dye mixture. Following the principles of the original experiment, all the food colouring mixtures suggested below start as a similar shade of green, but produce different banding patterns after electrophoresis.

In our experiments, the best results were always obtained using 1 x TBE buffer [3] solution (and gel). The presence of the buffer stops the dye bands from dispersing and gives clear, distinct results. Here is our suggestion of the best 4 dye mixtures:

- *Mixture 1* - Tesco green food colouring.
- *Mixture 2* - Tesco yellow food colour: Tesco blue food colour: Tesco red food colour (2:1:0.5 ratio).
- *Mixture 3* - Dr Oetker™ green gel.
- *Mixture 4* - Dr Oetker™ green gel colour and Dr Oetker™ purple gel colour (0.5:0.5 ratio).

As a cheaper alternative, the experiment was repeated using a 10 mM sodium hydrogencarbonate solution and gel. Although there was still a significant degree of dispersal and the bands appear "fuzzier", this still bore good results. The following 4 dye mixtures gave good results in this solution:

- *Mixture 5* - Tesco green food colour.
- *Mixture 6* - Timstar green powder food colour 0.1 g.
- *Mixture 7* - Timstar green power food colour 0.06 g and Timstar red powder food colour 0.03 g.
- *Mixture 8* - Dr Oetker™ green gel food colour.

It is still possible to purchase the original food colouring component dyes as a pack of powdered dyes from Scientific and Chemical (catalogue number EMZ 180 010, £64 for the complete set). To make up 4 green "blood" samples equivalent to the "wizard blood" samples in the original 2007 bulletin article [1], use the data in Table 1 as a guide. In this case, the sucrose

***Figure 4** - An array of different colours that can be produced by electrophoresing different supermarket food colourings in agar gels using TBE buffer.*

Item	Supplier(s)	Order code	Cost (as at August 2017)
Agar	Timstar Scientific and Chemical	AG 1092 AG005	£8.39 for 100 g £7.99 for 100 g
TBE buffer	National Centre for Biotechnology Education (NCBE) Timstar	– BT110100	£11.00 for 50 cm^3 10 x concentrate (makes 500 cm^3 1 x TBE) £21.86 to make 5 dm^3 of 1 x buffer
Powdered food colour (green)	Timstar	FC160115	£5.10 for 100 g
Powdered food colour (red)	Timstar	FC160100	£5.10 for 100 g
Food dyes set	Scientific and Chemical	EMZ 180 010	£64.00

***Table 2** - Table of suppliers and cost for non-supermarket items.*

solution increases sample density to allow easy loading. It is possible to run these on agar gels in just water, and this produces good results with a 4-tooth comb. As a slight improvement to the original protocol, running samples in either 10 mM sodium hydrogencarbonate solution produces really clear bands and could be better if using a 6- or 8-tooth comb (see Figure 3).

As an aside, the array of different colours that can be achieved using different supermarket dyes run on 1.5% agar gels in 1 x TBE buffer is striking. Figure 4 is a good example of several different supermarket dye mixtures. We have only included these as an interesting aside worthy of further investigation - because the mixtures are not all green, they are not suitable for the Wizard Genes practical.

References

[1] The wonderful wizardry of finding a gene (2007), SSERC Bulletin, **221**, 2-4.

[2] Food dyes and electrophoresis (2011), SSERC Bulletin, **237**, 2-3.

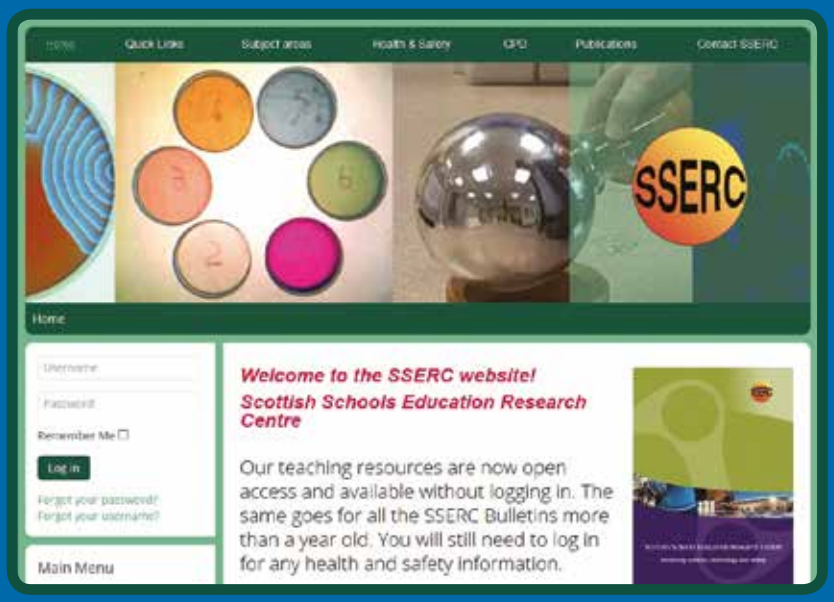
[3] To prepare a 5 x stock solution of TBE buffer Prepare a 5 x stock solution take 54 g of Tris base and 27.5 g of boric acid and make to 1 dm^3 in distilled water.

Why do I have to log in?

We have recently surveyed a large number of teachers and technicians, asking questions about our professional learning and our advisory service. The results are still being processed but we're very encouraged by what we have seen so far. We do take criticism very seriously and would like to address a comment about our website that appeared on several occasions.

Some respondents found it a nuisance to have to log in to access certain resources. The parts of the website that are password-protected include the health and safety advice and the most recent bulletins. SSERC is funded by local authorities as a shared service that gives advice and runs training based around effective, engaging, safe, exciting practical work. Local authorities can reasonably expect something for their money that somebody who did not fund SSERC could not access. This is why some of our material is not in the public domain. Classroom resources and bulletins over one year old are accessible to all, but if you are not logged in, the useful search facility is unavailable.

If you do not have a SSERC log in, please email registration@sserc.scot. Say who you are and where you work, and please use an email address linked to your workplace, i.e. do not use a gmail, Hotmail or Yahoo address or similar.



National 5 Biology assignment packs

As you will be aware the SQA has made changes to the Course Specification for National 5 Biology [1]. One of the major changes which will come into effect at the start of the 2017/2018 academic session is that practical/experimental/ fieldwork will become a mandatory feature of the assignment. The Biology Team at SSERC was commissioned by the SQA to produce 2 Resource Packs which could be used to support teachers and students with the implementation of this change.

Figure 1 *- Resource pack 1 Limiting Factors in Photosynthesis.*

Figure 2 *- Resource pack 2 Fertiliser and the Growth of Algae.*

These resource packs are available to download from the SSERC website [2]. We should point out that the packs are exemplars and that the suggested practical work is not mandatory. Many other practicals currently undertaken are equally appropriate and could be adapted to meet the new National 5 assignment guidelines. Over the coming months we will be looking to see how we might add to the SSERC pool of exemplars. Details of these will be made available on the SSERC website and in future bulletins.

The activities suggested in the packs are not new - they have featured in previous bulletins [3], are on the SSERC website and have been shared at SSERC CPD events; but the protocols have been adapted to meet the SQA specifications for the National 5 Biology assignment.

Each resource pack consists of 3 elements:

- a Teacher/Technician Guide
- a Student Guide
- a generic risk assessment.

The Teacher/Technician Guide provides background information on the biology relating to the practical work together with notes on the methods suggested in the Student Guides. There is also detailed information relating to necessary equipment and suppliers. To meet the requirement for candidates to, "*compare data/ information from internet/literature research with the experimental/*

Figure 3 *- Scenedesmus grown in 0.25 cm^3 concentration of Baby Bio™ for 10 days.*

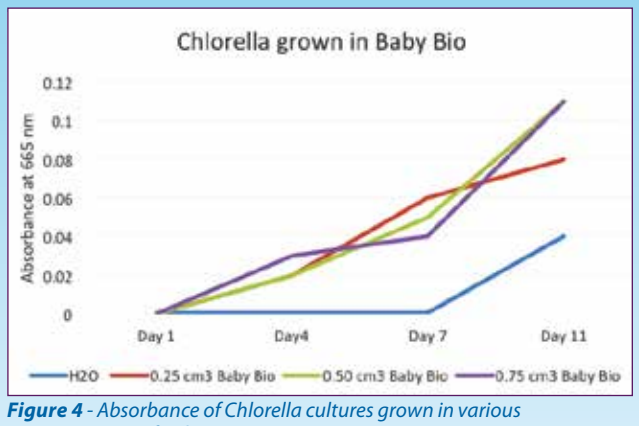


Figure 4 *- Absorbance of Chlorella cultures grown in various concentrations of Baby Bio™.*

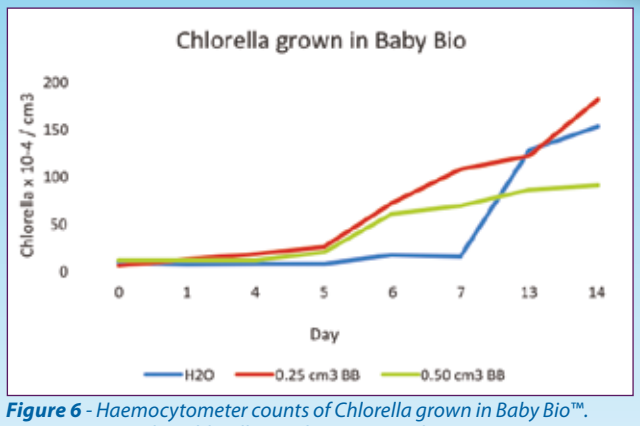


Figure 6 *- Haemocytometer counts of Chlorella grown in Baby Bio™. Counts expressed as Chlorella numbers x 104/cm³.*

Figure 5 *- Euglena grown in distilled water (top) and in Baby Bio™ (bottom) for 10 days observed at x 100 magnification.*

fieldwork data" [4] each Teacher/ Technician Guide contains a list of links to websites and literature sources that provide relevant data or information easily accessible by National 5 students.

The Student Guide provides a very brief introduction to the practical activities followed by detailed protocols for the suggested methods. In each case a separate protocol for the investigation of two possible variables is provided.

The generic risk assessment should be used as the basis for a risk assessment appropriate to the circumstances which exist in your own school/college/class.

Fertiliser and the growth of algae

The context for the activities described here is eutrophication - an increase in nutrient concentration in waterways that can lead to algal blooms. The practical activity is based on one described in *Algae a practical resource for secondary schools* (Society for General Microbiology, 2012).

The Student Guide provides protocols for setting up and carrying out investigations into the growth of populations of freshwater algae. Students can compare the size of the algal populations grown in fertiliser solutions over time by measuring absorbance of the algal cultures using a colorimeter. A suggested supplementary activity is to observe the cultures directly using a microscope. Some students might also compare algal growth over time by estimating population size by carrying out direct cell counts using a haemocytometer.

It is possible to use the basic method to investigate different variables: fertiliser concentration; fertiliser type. It would also be possible for different groups within the same class to carry out one of these investigations using different types of algae.

At SSERC we have set up investigations using 3 types of freshwater algae, *Scenedesmus*, *Euglena*, and *Chlorella*. Figures 3, 4, 5 and 6 show some typical images and data sets.

Limiting factors in photosynthesis

Effect of Light Intensity

The context for this activity is to offer opportunities for students to investigate how light intensity or temperature affect the rate of photosynthesis. The activities are based on the well-established system using immobilised algae [5, 6]. For the effect of light intensity, 2 protocols are suggested one

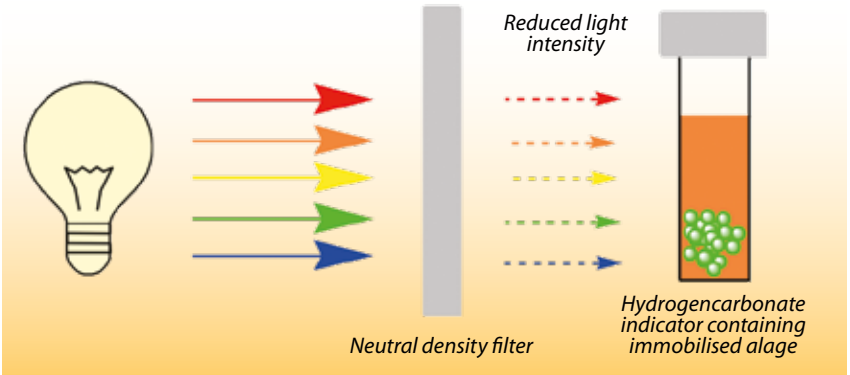


Figure 7 *- Using a neutral density filter to reduce light intensity in photosynthesis experiments.*

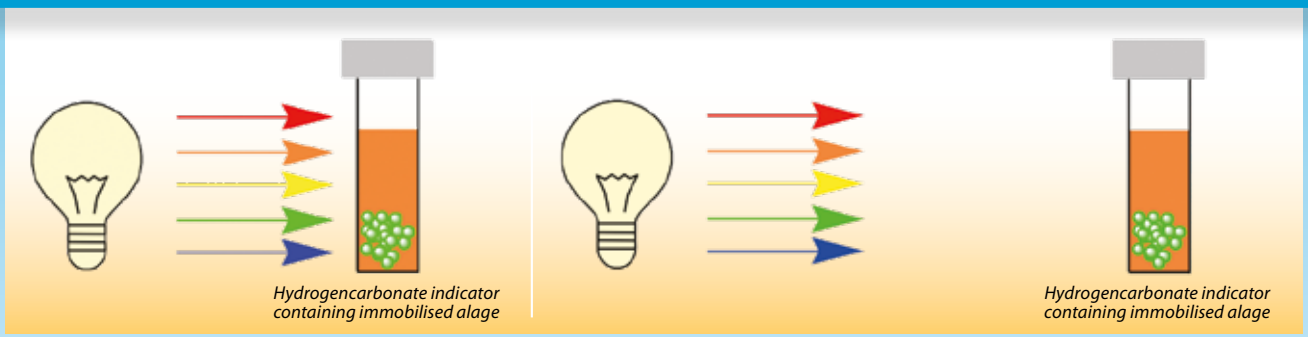


Figure 8 *- Reducing the light intensity in photosynthesis experiments.*

involving reduction of light intensity using neutral density filters and the other by altering distance of samples from the chosen light source (Figure 7 and 8).

The Student Guide sets out protocols for the experimental set-ups shown in Figures 7 and 8; absorbance changes can be conveniently measure using a colorimeter (580 nm). Figure 9 shows a sample data set.

Effect of temperature

The effect of temperature on the rate of photosynthesis can also be measured using immobilised algae although in our experience this is a slightly more challenging experimental set-up to put in place. A sample set of data is shown in Figure 10. The raw data for Figures 9 and 10 will be available on the SSERC website shortly.

The full National 5 Biology Assignment packs can be accessed on the SSERC website: http://www.sserc.org.uk/biology/biology-national-4/4239-test. Associated data sets can also be accessed from this page.

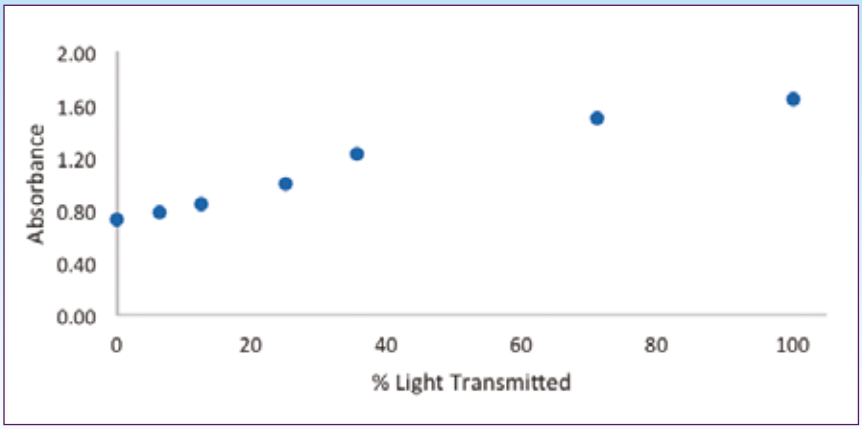


Figure 9 *- Change in absorbance (580 nm) after 90 min illumination for samples as per the experimental set-up in Figure 7 on page 11.*

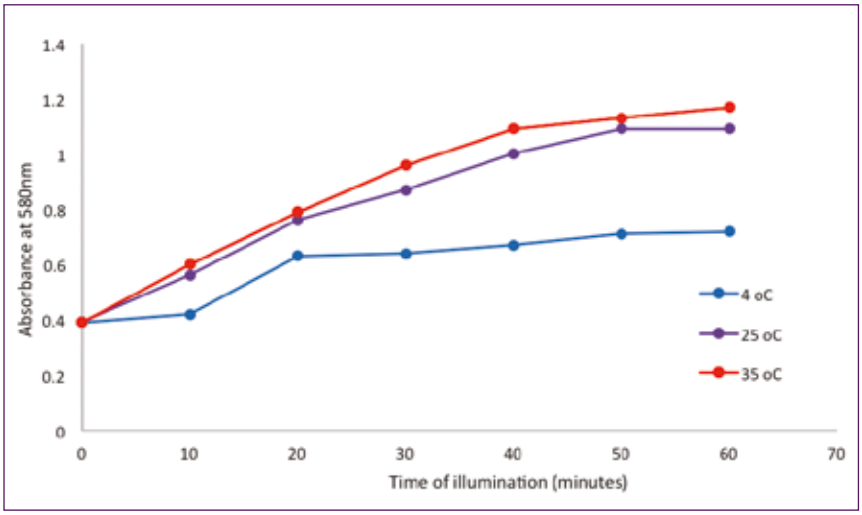


Figure 10 *- Effect of temperature on the rate of photsynthesis in Scenedesmus quadricauda.*

References

[1] National 5 Course Specification 2017-2018 session, June 2018 at https://www.sqa.org.uk/files_ccc/BiologyCourseSpecN5.pdf (accessed September 2017).
[2] SSERC website at http://www.sserc.org.uk/biology/biology-national-4/4239-test.
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[4] National 5 Course Specification 2017-2018 session, June 2018 at https://www.sqa.org.uk/files_ccc/BiologyCourseSpecN5.pdf (accessed September 2017).
[5] Eldridge, D. (2004) A novel approach to photosynthesis practicals. *School Science Review*, **85** (312), 37–45.
[6] Andrews, K., Beaumont, P.C. and Crawford, K. (2015), Measurement of limiting factors in photosynthesis. *School Science Review*, **96** (356) 31-35.

Manual screwcutting: the ins and outs

To help with the process of screwcutting threads on or into metal while working on practical metalwork coursework, we have put together this quick "one stop shop" guide. It contains need to know information on cutting internal threads using taps. In a future bulletin, we will look at how external threads are made.

As with most metalwork or engineering processes, whole books can be written on the subject, but let's look at the basics...

The screwthread is a very important aspect of engineering. It is used to hold parts together (e.g. bolt and nut) and to transmit power (e.g. vice screw). A screwthread is really a helical spiral which is specified by:

1) The name or type of thread system;
2) The size of thread major diameter;
3) The series. (coarse pitch, fine pitch, etc.)

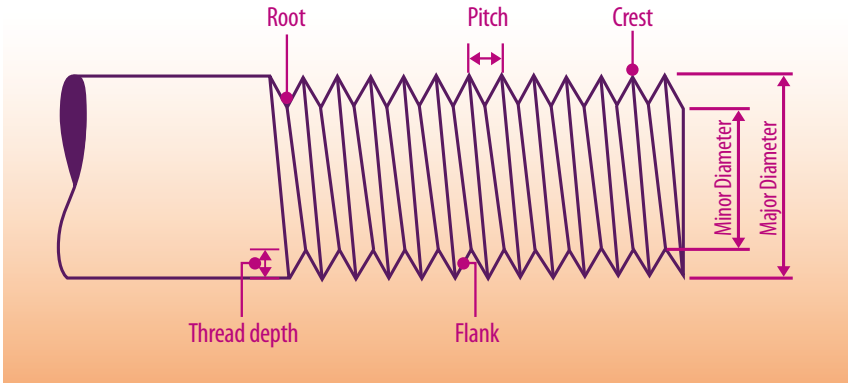

Figure 1 *- Screwcutting terminology.*

Thread forms - ISO Metric screwthreads

International Standards Organisation (ISO) metric screwthreads are a range of threads that have been approved by the British Standards Institution. ISO metric threads may be either Coarse or Fine series (or pitch). The ISO metric coarse range of threads covers most of the work undertaken in industrial and school workshops and, as such, is called "ISO Metric". This range is designated by the letter M followed by the nominal diameter and the pitch (both in millimetres):

e.g. M6 x 0.75
i.e. nominal diameter 6 mm and pitch, 0.75 mm.

e.g. M6 x 1
i.e. nominal diameter 6 mm and pitch, 1 mm.

when a coarse thread is intended it is usual for the pitch not to be indicated. Thus M6 x 1 can be shown simply as M6.

Other thread forms

There are a number of other thread forms available. ISO Unified Threads are also recognised by the British Standards Institution and like ISO Metric threads, have a range of both coarse and fine pitches. Unified threads are based on imperial dimensions and are designated by a fraction of an inch followed by UNF (Unified Fine) or UNC (Unified Coarse). For example, 1/4" UNF or 3/8" UNC. Older thread forms such as BSW (British Standard Whitworth, BSF (British Standard Fine) and BA (British Association) have been superseded by the ISO Metric and ISO Unified threads. However, as many of these threads exist on various equipment and machinery, they are still available.

Taps

An internal screwthread is cut, in a previously drilled hole, using a tap. Taps are made from high speed steel screwthreaded and fluted to form cutting edges. The ends of their shanks are square to enable the tap to be held securely in a tap wrench.

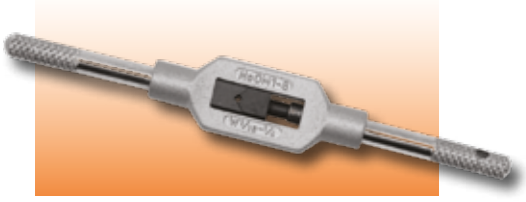

Figure 2 *- Tap wrench.*

Taps are available in sets of three and are used in the following order:

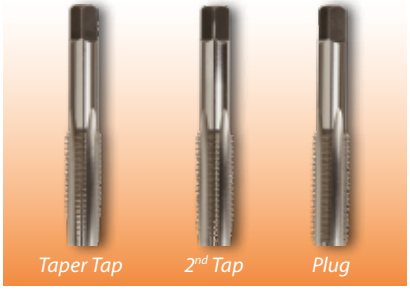

Figure 3 *- Threading taps set,*

Tapping an internal thread

For example, to tap an M8 thread a core hole must be drilled using a 6.8 or 6.9 mm diameter tapping drill. The taper tap must then be started with its axis parallel to the centre line of the hole; if not a "drunken" thread will result (see Figure 4 and 5).

Figure 4 *- To cut an internal thread the taper tap must be used first.*

Figure 5 *- Even and square pressure must be applied to initially start the cut.*

As soon as the tap cuts it should be checked for alignment with an engineer's square.

The tap should be turned clockwise half a revolution to cut the thread and back a quarter turn to clear the swarf (see Figure 6 and 7) This is followed by a second or intermediate tap which is tapered for the first few threads only.

Figure 6 *- Tap wrench is turned clockwise half a revolution.*

Figure 7 *- Tap wrench turned back quarter of a turn to break and clear the swarf.*

Finally, the plug or bottoming tap is used to cut the full thread (see Figure 8). A cutting oil or compound should be used to lubricate the work as the thread is being cut. This will prolong the life of the tap and allow for an efficient cutting action which in turn produces better quality threads.

Tapping sizes

Table 1 gives all the information required when tapping a metric hole from M2 to M12.

Broken taps

Broken taps always present a problem as there is rarely enough tap left protruding for easy extraction with pliers.

A tap extractor (see Figure 9) could be used. However if this fails then other means must be found. For example, it is sometimes possible to punch the tap out from the other side, or it may become loose enough for extraction when heated. The tap could be annealed by heating after which it might be possible to drill it out.

Figure 8 *- Once complete, the 2nd and plug tap should be used to fully cut the thread.*

ISO Metric Coarse Pitch Threads		
Diameter	**Tapping Drill Size**	**Clearance Drill Size**
2	1.6	2.2
2.5	2.1	2.7
3	2.5	3.2
3.5	2.9	3.7
4	3.1	4.3
4.5	3.8	4.8
5	4.2	5.3
6	5.0	6.4
8	6.8	8.4
10	8.5	10.5
12	10.2	13

Table 1 *- Tapping & clearance sizes.*

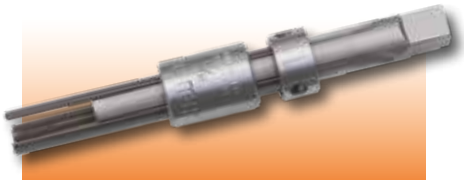

Figure 9 *- Tap extractor.*

Check out the video link!

http://www.sserc.org.uk/images/Technology/Video clips/General Bench Skills/internal threading.mp4

Back with the PSSR - revisiting the pressure regulations

In Bulletin 259 [1], we issued guidance on the testing of pressure equipment such as steam engines and autoclaves. We highlighted a particular issue with thermostatically-controlled autoclaves such as the Prestige Medical.

In any pressure vessel, as temperature increases, pressure increases. If the pressure gets too high, a safety valve opens. In a thermostatically controlled autoclave, circuitry monitors temperature and shuts off the heater before the temperature reaches a level where the corresponding pressure would make the safety valve open. Such autoclaves still have safety valves in case the thermostatic control fails. As we pointed out in Bulletin 259, the safety valve can therefore only be checked either by:

- Disconnecting the temperature regulating circuitry, monitoring temperature and allowing pressure to rise to a level where the valve opens;
  Or
- Testing the valve using calibrated equipment to ensure that it will open at the appropriate pressure. This may involve removing the valve and attaching it to a test rig or connecting an airline to it whilst it is still in place.

These are not tests that schools are going to be able to carry out inhouse. We have heard that some companies who test thermostatically controlled autoclaves may not be carrying out either of these tests. They monitor the rise in temperature with time without disconnecting the thermostatic control circuit, and waggle the safety valve to check that it is not stuck. Discussions between our sister organisation CLEAPSS, the Health and Safety Executive and ourselves have led us to conclude that this does not satisfy HSE. HSE issues guidance in the form of an Approved Code of Practice (ACoP) [2]. Paragraphs 109 and 130 of the ACoP for PSSR state:

109
...The examination should include checks that the devices [safety valves] function correctly and are properly calibrated or, alternatively, that they have been replaced by recently tested units.

Thermostatically controlled autoclave. Note the unique identifier (numeral 5) written on it.

130
At the end of the examination, the competent person should be satisfied that the protective devices, especially any safety valves, have been tested and set correctly...

Phrases like "calibrated" and "set correctly" are unambiguous. It is not enough to know that the valve works. We need to know that it works at the pressure at which it is required to work.

We are pleased to note that those who have followed the "way through the woods" outlined in Bulletin 259 appear to have found it to be trouble-free.

References
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[2] http://www.hse.gov.uk/pubns/priced/l122.pdf (accessed September 2017).

Soldering on

Practical Electronics is proving to be a popular course in a number of schools. Here we summarise our advice on safe soldering.

Type of solder to use

Solder contains a flux to make it flow. If the solder you use has rosin (also called colophony) as flux, you must install local exhaust ventilation (LEV). Small units that look like desktop fans with filters are not suitable. In the majority of cases, it makes much more sense to buy rosin-free solder. Even if you use rosin-free solder, at the very least, the classroom or prep room should be kept well ventilated throughout the time that soldering is done. If soldering is an occasional timetabled activity, then natural ventilation is likely to be a sufficient control. If a technician spends large parts of their working time soldering, LEV should be considered. It is not necessary to use lead-free solder, but please see the section on protection against ingestion.

Electrical safety

As well as using heat-resisting insulation on the flexible cord, SSERC recommends using low-voltage irons for pupil use. The preferred voltage is around 24 V; the preferred wattage is around 50-60 W for ease of work. The electricity supply should have accessible manual controls for isolation and cut-off (Bulletin 209) in addition to automatic controls (fuse or MCB, and RCD).

Protecting against burns

A bench stand for each iron is essential: it helps reduce the risk of skin burns.

There is a small, but foreseeable risk of injury to eyes from being touched by the hot tip of an iron. Safety glasses should be worn, preventing harm. The level of lighting at the bench should be sufficiently good to let users work safely.

Protection against ingestion

There is a risk of ingestion of heavy metals and other toxic substances from debris littering worktops. This debris can be picked up on clothing, contaminating food at a later time at another place. The risk is reduced by cleaning worktop surfaces at the end of each lesson by sweeping debris into a dustpan, and wiping surfaces clean with a damp disposable towel. Pupils should be instructed to wash their hands and brush their clothes at the end of a lesson. Teaching and support staff could wear lab coats.

Instruction and supervision

Finally, the teacher should carefully instruct pupils on how to solder and work with circuit boards by demonstration and practice exercises. Soldering operations should always be continuously supervised.

The SSERC Bulletin is published by SSERC • 2 Pitreavie Court • South Pitreavie Business Park • Dunfermline KY11 8UU
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