Element sets
Teachers' Notes

February 2025

I hope you and your students find this element set useful and inspiring. If there are any issues or feedback, feel free to contact me (Prof. Stuart Batten, Monash University, stuart.batten@monash.edu). Below are some notes on the sets; **it is important that you at least read the section on safety and care of the sets**.

Safety and care of the sets

These sets are intended for secondary school students only, and though the samples are perfectly safe if the jars remain closed, as with all chemicals supervision at all times is highly recommended. Full safety details (in the form of SDS forms) are available at https://elementsets.net/resources . The suggested hazard labelling is also given on this same web page (and is included in each set) – this labelling covers the contents of the whole set collectively, which I suggest is stored together rather than being broken up. Once you have received the sets I take no further responsibility for their safe use; it is then your responsibility to make sure they are used appropriately and safely.

While most of the samples are very safe in the elemental form, I suggest particular care is taken with Cd, S, In, Sb and Te. The main hazards are through ingestion, inhalation of dust, or compounds of these elements; with proper care these risks should be minimal. Again, full details are in the SDSs.

Nonetheless, for reasons of both safety and the long-term care of the sets, I HIGHLY recommend that the jars are carefully glued shut (except N, which is just an empty container full of air, which can double as a 'backup' if one of the other sample jars breaks at any stage). This will prevent curious fingers opening the jars, with inevitable loss or damage to the samples over time, as well as exposure to the samples themselves (which is not ideal for a few of the elements described above).

Please note that you need to **be very careful gluing the lids shut**. **Do not use superglue, Araldite, or any other cyanoacrylate based glue** as it can cause significant 'frosting' of the containers, particularly if more than necessary is used or it is allowed to dry in a sealed container. This is presumably due to the containers being made of polyethylene, polypropylene or similar material, which are not compatible with cyanoacrylate glues. This can be further exacerbated if fumes are circulating in a sealed container while drying (which applies to *any* glue type).

The **best glue to use is Clear Liquid Nails**, which does not frost the containers. Place a small dollop at the top of the thread on the base, screw the lid on, and then let it dry for 24 hours in the open. It is then best to test if the container is permanently sealed - occasionally one will unscrew again, in which case just repeated the process.

An alternative to gluing the lids is to put a small piece of clear sticky tape on the side (but not the top or bottom faces through which the samples are viewed), taping together the lid and base. This is obviously less permanent than gluing the lids, and will only discourage opening of the containers, not completely prevent it, and is thus not the preferred option.

Note that you may have received the Fe, C, Ga and S samples contained in their own separate small bags. This is mainly to ensure that the jars don't unscrew themselves in transit, resulting in the spilling of their contents. This can happen very occasionally, and these samples are particularly problematic if that happens as they're either fine powders (Fe, C, S), or possibly liquid (Ga). These bags can be removed once you receive your sets.

I should also mention the Ga sample. Gallium melts at 29°C, so what are currently nice shiny pellets in the Melbourne winter will almost certainly melt at some stage over the next 12 months. This will likely result in it smearing around the inside of the jar, giving a mirror effect. Gallium also has a tendency to 'supercool', meaning it can remain liquid even after cooled back down below 29°C. This is perfectly normal, and indeed unavoidable, but I also think the melted, 'smeared' version is just as interesting as the shiny pellets they started off as. It also makes an interesting talking point for the students – in winter samples at Darwin schools are likely to be liquid while the equivalent samples in Hobart will be solid!

If any of the sample jars open in transit you should be able to just pick the pieces up with tweezers and pop them back in the jars. If more than one open and you're having trouble identifying which-is-which just send me a photo and I can let you know (or alternatively, the pictures at the tops of the individual element pages in the booklet will also often give a clue). If at any stage the jars break, replacement ones are pretty cheap on eBay – just search '3g nail container' and you'll see lots of options. As mentioned above, the N sample is simply air (78% pure nitrogen!), so if you don't glue this one it can be used as an easily replaced 'spare' container if ever needed.

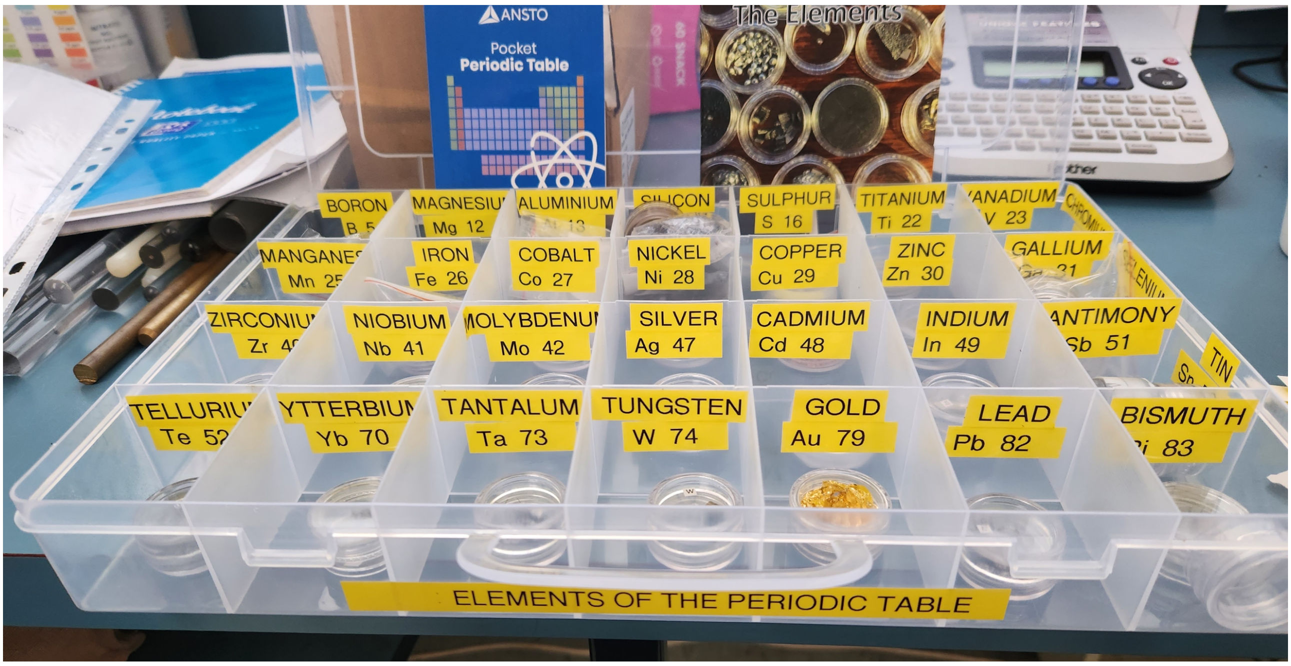
Storing and displaying the sets

The sets are designed to fit comfortably (along with the booklet and safety label) in the 1000ml takeaway container they are supplied with. Some versions of the sets, however, contain slightly larger individual sample containers, which can make it a tight fit unless the individual containers are packed efficiently. Below is the best way I have found to pack the samples (note that the plastic bags are not needed once you have the set). The other advantage is that by backing this way you can quickly see if a sample has gone missing. Note that this is for the larger container types; the smaller types may pack a little differently.

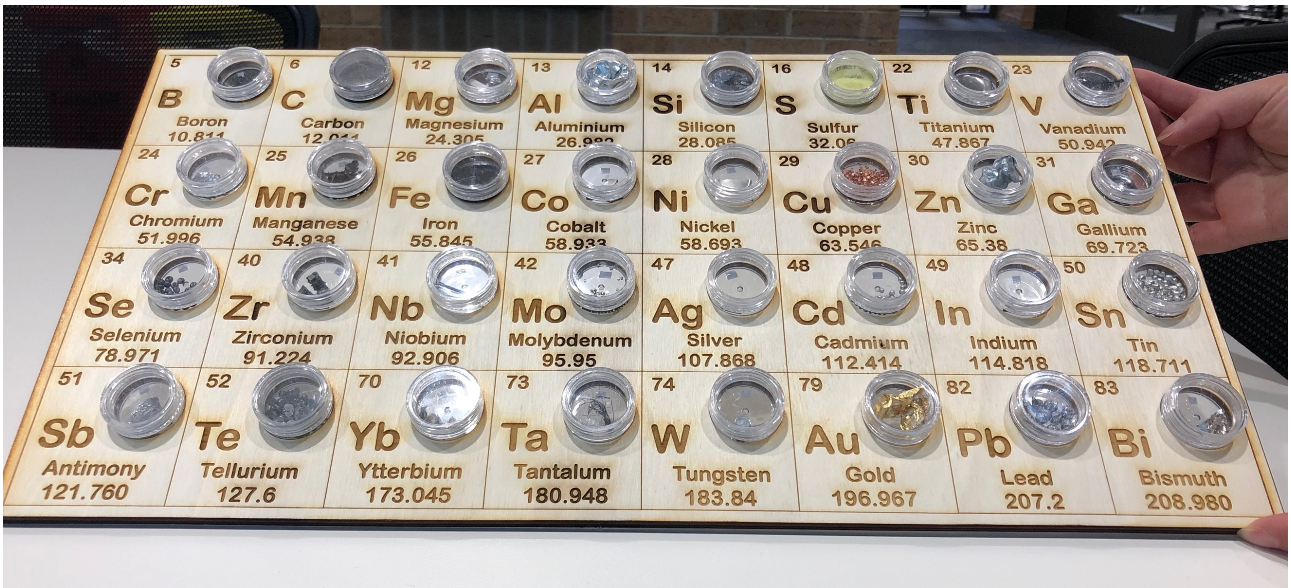
Best way to pack the samples – 22 samples on the bottom layer (left), followed by 15 samples on the top layer (right).

While the sets are designed for storage in the takeaway container, many schools prefer to move the samples to displays. Below are just three suggestions (of many) that have come from existing recipients of the sets.

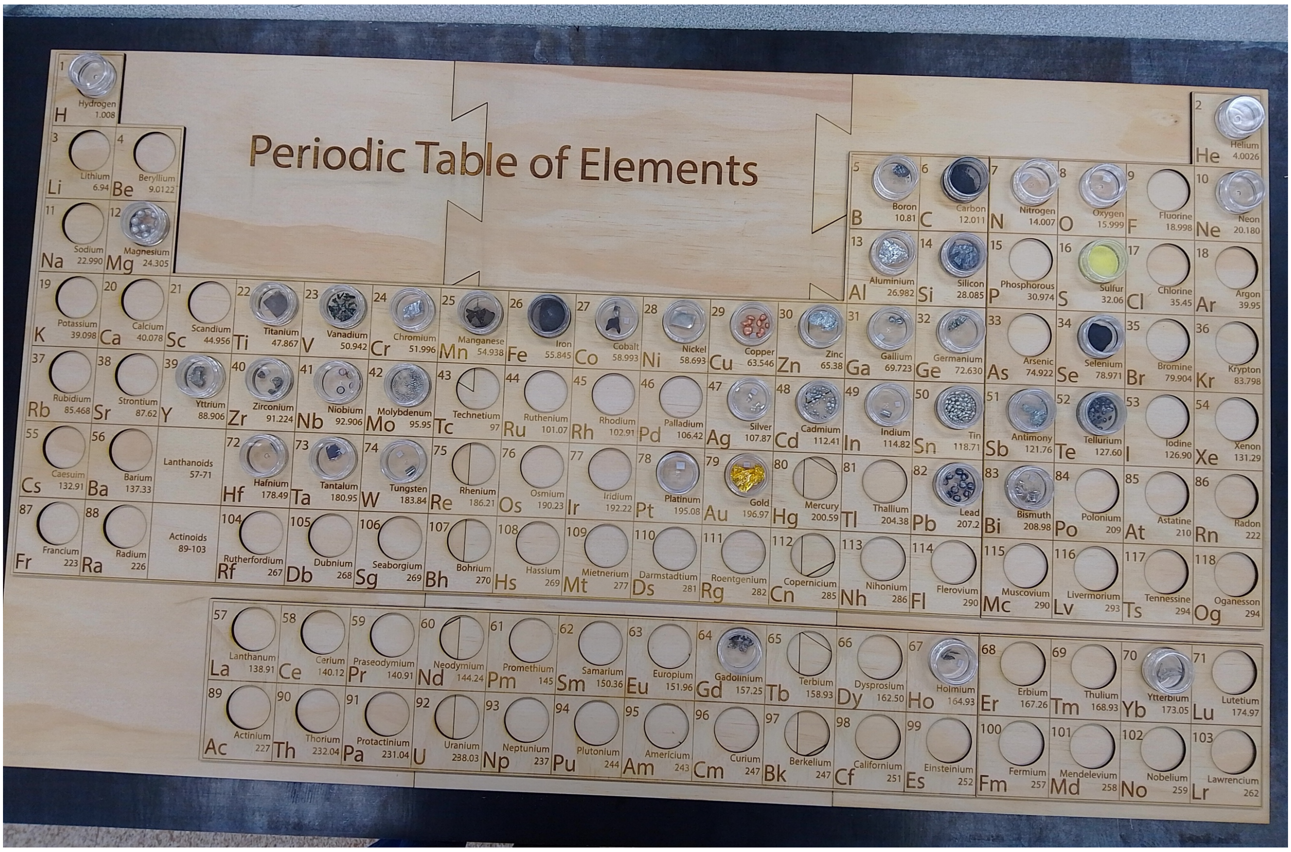
This display is great for putting on the set on show when not being used, as well as keeping the samples accessible for students to remove and examine individual samples. These can be found easily on eBay or Aliexpress (search '50 nail container display').



Plastic display box, easily obtained from craft shops or fishing tackle shops. Note that there are more samples than spaces, which has been solved by putting two samples in some slots and having a second label on the edges perpendicular to the main ones.



Of course, you could always ask your woodwork teacher nicely if they could come up with something, like this spectacular display.



The files for this amazing laser-cut display are available on the elementsets.net website.

Expanding the sets

While there are 37 elements in each set, there are obviously more on the periodic table that can be collected (though not all). I have deliberately designed the sets so that it is easy to expand (or even duplicate) the set further if you so wish. As described above, the empty jars are readily available on eBay. Many elements can also be purchased from eBay.

The jars were originally based on a similar range available online at Luciteria.com, however Luciteria appear now to have discontinued this series (as of September 2023). However, you can still buy individual samples from them or other suppliers, who all have large ranges of elements to purchase (often including specially designed ampoules for gases and reactive elements), and then put in your own pre-sourced empty containers. Luciteria, in my experience, have some of the best priced and nicest samples, but other specialty dealers in pure elements include onyxmet.com (cheap, also recommended), novaelements.com (generally more expensive, but their small gas ampoule sets are pretty good and are small enough to fit inside the jars), and peguys.com (I've had limited but good experiences with them). Just make sure the samples you source (particularly those in ampoules) are small enough to fit into your containers.

One suggestion for expanding the set over time might be to have (for example) the VCE Chemistry class each year vote on which elements to add to the overall set that year, as a lasting legacy to the collection after they leave! You could even run it like a 'March Madness' style runoff over several rounds of voting, starting with say 16 elements and have it all converge on one winner (or two if you want to build up your set quicker).

Feedback

Your feedback on these sets is valued. Firstly, I ask that everyone sends me a quick email to let me know when you've received yours. It would also be helpful if you could let me know in what condition they arrive in. Did any of the jars open or break in transit?

Secondly, I'll be interested if you have any great suggestions for classroom activities, or to hear how you're using them in the classroom. I've listed some possible classroom activities below, but I'm always keen to hear new ideas.

Finally, it would be great for possible future projects (e.g. another round of sets or starting new outreach projects along similar lines) that if you ever get the chance, I'd be very happy to receive e.g. photos of the kids using the sets or similar feedback (although I realise that there may be privacy issues around this). It would particularly helpful to show potential sponsors of future projects the impact of this one (as well as a small thank-you to pass onto the current sponsors when I get the chance), and nothing will be as effective as pictures of students all around Australia using these current sets.

Classroom ideas / discussion points

These are some very rough musings, so take them with a grain of sodium chloride, and obviously adjust for year level. There are also full class plans being developed with will be available on the website (elementsets.net).

• Give kids an element and get them to do a project on them. Where can it be found? What is it used for? As an element or in compounds. How is it 'mined'? What are its distinctive properties? Where is it on the periodic table? Is it a metal, non-metal, or metalloid? Does it form allotropes (e.g. graphite vs diamond)? What is its electronic configuration? How heavy is 1 mole of atoms? What sort of bonds does it make in compounds? Is it magnetic? Does it conduct electricity? Could you make it into foils, sheets or wires? What temperature does it melt at? How are the atoms arranged in the element? How do they bond to each other? When was it discovered, and by who? Is there something else in the classroom that contains that element? How is it similar and how is it different to the elements around it on the periodic table?

• Turn it around. Hide the label (e.g. a small round Band-Aid with the soft bit over the label so it can be removed later without damaging the label, or maybe a piece of paper over the label and then sticky tape). Get the students to try to identify the element. What can they observe about it? Is it a metal, non-metal or metalloid? Is it a foil, wire or sheet (which are properties of metals)? What colour is it? How dense is it? Is it attracted to a magnet? Is it a solid, liquid or gas? Even if they can't identify the element precisely (many of them would be difficult to narrow down to just one possibility), they could still take an educated guess (especially if they're given the 33 possible options in this set to narrow it down from). Could be done individually, or done as a group for some or all of the elements in the set (e.g. Here are 3 samples – which one is Ni? Which one is S? Which one is N?). If you could open the containers (which I don't suggest), what further tests might you do to try and identify the sample (even to the point of destroying the sample - **thought experiment only**)?

• Place yourself in Mendeleev's shoes. Ignore the labels; based on what you observe about the samples, how would you sort them? That is, arrange your own 'periodic table' with the samples. What principles and trends are you using to arrange them? What 'properties' might you sort by (lustrous, density, form (powder, lump, sheet, …), state (solid, liquid, gas), …)? What seem reasonable properties to sort them by, and what don't?

•Arrange the samples into groups based on the valence orbitals – i.e. s-, p-, d- and f-block. Do they have common properties within each block?

• Gallium could be cooled in a fridge to give a solid, then should melt again in a student's hand, through gentle heating (e.g. a microwaved wheat pack) or by itself on a warm day.

• The iron powder gives cool patterns if a strong magnet is held next to it. Why? At least one other element in the set is also attracted to the magnet – which one is it? Are there others?

• The W sample is a small cylinder. The students could weigh the sample (using the empty N container as their 'zero'), and measure the dimensions of the cylinder (which can be done without opening the jar). They could then calculate the density of W. How close to the true value did they get? How does it compare to other elements? Might also be possible for Ag, and maybe Ni or Ti (though the sheet thickness is a little hard to measure accurately through the jar walls). Note: the W samples were the last to be prepared, and some of them ended up in slightly different jars to all the other samples. If the W jar looks different to the others, then it is 1g heavier than the 'regular' jars (i.e. if using the empty N container as the 'zero', take an extra 1g off the apparent weight of the W sample to get the true sample weight).

• Again, using the N container as the 'zero', the weight of each sample can be measured. Which sample has the most atoms? Give the answer in terms of both moles and actual numbers of atoms. If two of the samples were to react, which is in excess? For example, if the Ti and S samples were to react to form "TiS_2", which element would have some left over after the reaction? How much would the final sample of TiS_2 weigh? If the carbon sample caught fire, how many molecules of CO_2 would be produced? What volume would this occupy at STP? Another variation might be to ask the students to first "guess the number of atoms in the jar" for their sample. Perhaps give them a multiple answer question first to hone their answer. Then calculate the actual answer (as above). Which student/group got closest to the real answer?

• What elements might you combine to 'Make' a compound? Give each student a sample and ask them to find someone in class who has a different element and make a compound (or Alloy). What kind of bonding might the compound have? Would there be transfer of electrons between the elements (redox)? Predict some properties for that compound.

• The Mn sample is rather brown, even though pure Mn is silver in colour. Why? (It's oxidation). Similarly, why are the wires of Nb all different colours? (They've been anodised – an electric current is passed through them to create a very, very thin surface layer of oxide – the colour is dictated by the depth of the oxide layer). Al and Ti can also be anodised to give different colours. Also, while the Bi sample in these sets is nice and silvery in colour, Bi crystals can be grown that have rainbow patterns – this is the same effect (i.e. surface oxide layers giving varying colours depending on depth). A quick Google will turn up pictures of multi-coloured Bi crystals. The same effect (very, very thin layers of a second material) is also responsible for the rainbow effects of thin layers of oil on water. If you look closely at the ends of the Nb wire pieces, where they've been cut, you should see the silver colour of the 'pure' metal.

• While on the topic of oxidation, the lanthanoid samples will likely oxidise over time. You may wish to keep an eye on how this progresses – I'm really not sure how they are going to end up 5, 10, 15 years from now (especially in regions that have high humidity). If it does end up oxidising completely then I would just treat this as another interesting talking point. For example, at time of writing the Yb samples are a lovely golden colour (which is due to a small amount of oxidation already) but are still clearly metallic and reasonably pristine. Yb is at the end of the lanthanoid series, and thus much more stable than the early members of the series (which can oxidise very quickly in air), so the comparison to Gd and Ho might be interesting. But another talking point with the students is how might you store samples of e.g. La, Ce or (especially) Eu without them oxidising? (Store under an inert gas)

• What elements are missing from these sets, and might you suggest a reason why? Unstable? Too expensive? Too toxic? Too reactive? Too difficult/fiddly to handle (e.g. gases)? Radioactive?

• As mentioned above, the "N" sample is simply air. See if the students can work that out. What other gases are likely to be in there, "contaminating" the sample? Which of these are elements and which are compounds? I initially thought about including this sample as a bit of a joke, but upon reflection it's a useful way of showing that some elements, in their elemental form, are around them all the time (nitrogen, oxygen, noble gases). It also emphasises that not all elements are solids in their elemental form.

• Bi is very, very weakly radioactive, so this can be used as a lead-in to a discussion on radioactivity. What is a half-life? How much Bi will be gone after 1 million years? What other elements are radioactive? What are isotopes, and why do the half-lives of different isotopes vary? Etc…

• The Gd and Y samples look very, very similar (not surprising, as they're both rare earth elements with similar chemistry). But hold a strong magnet near both and you'll soon be able to tell them apart – Gd is attracted while Y is not. There are a couple of other elements in the set that are attracted to a magnet – which are they?

• Element Bingo. Rather than call out the name directly, call out properties (e.g. no. of protons, AMU, show (or describe) sample, describe use). Use either dedicated bingo boards or the periodic table itself.

- Element “Who Am I?”. Cards with hints for each sample. Half students with cards, half students with samples.

- Rankings. Students have one sample each and try to put themselves in the right order (from least to most, earliest to latest, etc.) for various properties, such as: date of discovery, importance, abundance, price (either per kg or of their actual sample (hint: they’re not all the same weight)), atomic radius, first ionisation energy, and so on.

- The samples might make interesting objects to look at under a microscope.