Radioactivity for technicians

Radioactivity can be one of the more challenging topics for students to grasp as the content is based around something that is invisible. Radioactive sources are a valuable teaching tool for this topic but it is important to have a sound understanding of all the health and safety requirements that accompany holding them. Not all demonstrations and activities require radioactive sources. Resources that visually model concepts are just as beneficial.

Understanding radioactivity as a technician

I believe it is important for technicians to have a basic grasp of the knowledge we expect our students to have. Being familiar with content provides an opportunity for technicians to develop additional resources that aid student understanding of more difficult concepts. This is especially true for radioactivity as it is something students cannot easily observe. So, spend a bit of time getting to grips with what you expect the students to understand.

Holding sources: Is it really worth it?

In my opinion - yes! A considerable misconception surrounding radioactive sources is their appearance. If you ask a student to describe how a radioactive source looks, more often than not, they will conjure an image of a glowing green object that is highly dangerous. Holding radioactive sources provides the opportunity to dispel this delusion and showcase radioactives as ordinary looking objects that are able to be handled safely.

In addition, holding sources can also facilitate the use of:

- A Geiger-Müller (GM) tube and counter
- The different properties of alpha, beta and gamma emissions
- A spark counter - a noteworthy alternative to a GM tube as it allows visual and audible detection of alpha radioactive emissions
- An ionisation chamber - a great demonstration of how alpha sources ionise air and generate a small current (i.e. how a smoke alarm works)
- A cloud chamber - an excellent way to visualise radioactive emissions

There are of course certain drawbacks to holding sources. Tasks such as annual leak testing and ensuring paperwork is kept up to date can be time consuming. Furthermore, the expense involved in replacing sources like Cobalt-60 can pose issues especially with already overstretched budgets. A new Cobalt-60 cup source costs upwards of £1000 and given a half-life of 5 years the source will become spent in a relatively short time.

Alternative Isotrak Caesium-137 sources are slightly cheaper and have a prolonged half-life of 30 years making them more favourable and a greater long term investment when a Cobalt-60 needs replacing [Ref: CLEAPSS PS078].

In my opinion, the educational value gained from holding sources far outweighs the drawbacks.

Health and safety

Understanding the health and safety and legal requirements when holding sources can be challenging and take some time to get to grips with. If you're starting out with no prior knowledge and looking at the 108-page L93 document on CLEAPSS with a slight panic, I would recommend heading straight for page 89. This is a basic checklist of everything you should have in place/be doing when holding radioactive sources and is therefore a great starting point. Any questions or queries, CLEAPSS are always on hand to provide advice.

CLEAPSS strongly advise that the radiation protection supervisor (RPS) should not be a technician but instead should be a member of teaching staff. The reasoning being that technicians may lack the relevant authority to perform the RPS role fully. It is therefore not a comment on technician knowledge or expertise. Technicians may work together with their RPS to assist with safe storage, monitoring, and record keeping. CLEAPSS recommends that a teacher as the RPS and a technician as the deputy RP is a great combination. I find that this collaborative approach between RPS and technician works really well. [Ref: CLEAPSS PS075]

It's not all about radioactive sources

Demonstrations and activities within this topic aren't just limited to working with radioactive sources. Additional resources are a valuable tool for aiding learning and consolidating knowledge. Examples of these are:

Modelling Rutherford's alpha scattering experiment: This demonstration simulates how the alpha particles that Rutherford fired at the atoms of gold mostly passed straight through the atom which led him to the discovery of the positively charged nucleus. Here the hula hoop is the atom with the small set of beads (held in place with inviable wire) in the center representing the nucleus and the outside hoop representing the electrons that circle it. The nerf bullets are the positively charged alpha particles that were fired at the atom (Fig. 1).

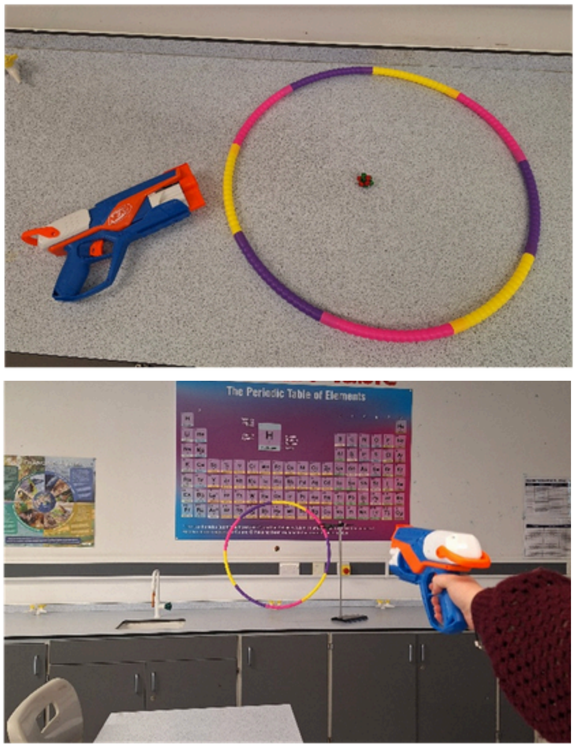

Figure 1. Modelling Rutherford's alpha scattering experiment.

Safety note: Ensure the area where the nerf bullets will be fired is clear of people. The person holding the hula hoop atom should wear eye protection. Do not allow nerf bullets to be fired towards others.

Modelling changes to a nucleotide during radioactive emissions: Ping pong balls that have been glued together represent a radioactive nucleotide with the orange balls being protons and the white neutrons. A detachable helium nucleus (held in place with Velcro) simulates an alpha emission (Fig. 2a). A beta emission is simulated by removing a halved white ball (that sits on top of an orange ball) show the change of a neutron a proton and a small blue bead represents the high-speed electron that is emitted from the nucleus (Fig 2b.)

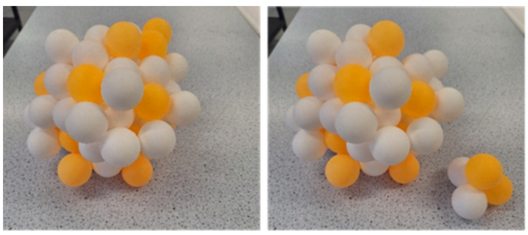

Figure 2a. Modelling an alpha emisson.

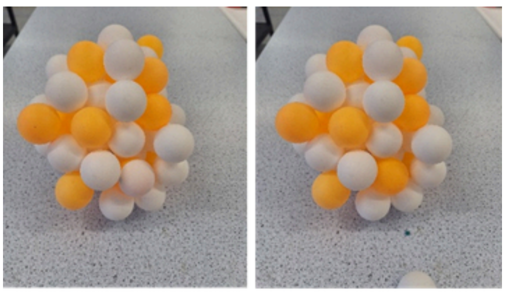

Figure 2b. Modelling a beta emission

Modelling radioactive half-life with cubes: This hands-on simulation models radioactive decay using cubes that have been marked on one side. The cubes represent the atoms of a radioactive element are thrown. Those that land marked side upwards are considered to be decayed and are counted and removed before the process is repeated. The number of decayed cubes each throw decreases exponentially allowing the data collected to be utilised for graph plotting. Data may also be visually presented through the stacking of cubes or collection of cubes in measuring cylinders (Fig 3a). Alternatives to cubes are dice, tiddlywink counters, and coins.

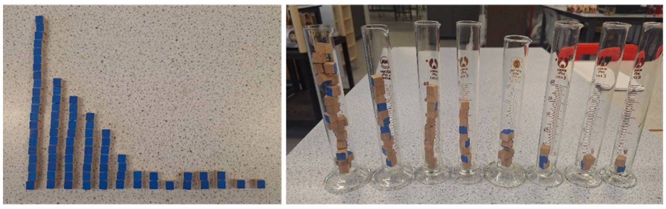

Figure 3a. Visual presentation of the exponential curve created from the cubes.

Tech tip: Throw the cubes in a Gratnells tray to prevent them from getting lost (Fig. 3b).

Modelling radioactive decay and half-life with popcorn: This demonstration is a simple and visual way of modelling radioactive decay and the concept of half-life. Unpopped kernels represent atoms of a radioactive element (parent isotope) and the popped popcorn pieces represent atoms that have decayed (daughter isotope). As in radioactive decay, the popping of the kernels is random and cannot be predicted. In the activity a fixed number of kernels are added to a popcorn machine and the number of popcorn pieces produced every 10 seconds are counted which produces an exponential decay curve. The rule about not eating in the lab should be strictly enforced!

Modelling radioactive half-life liquids: This activity models half-life using the foam produced from pouring carbonated drinks (such as alcohol free beer). The liquid is poured into a measuring cylinder and the level of foam is recorded at intervals over a period of time. The level of foam can be measured using the graduations on the measuring cylinder. Alternatively, masking tape can be attached to the measuring cylinder and the foam levels marked on the tape (Fig. 4). With this approach, the tape can be removed and directly placed onto graph paper (y-axis) to provide the data points for plotting a graph.

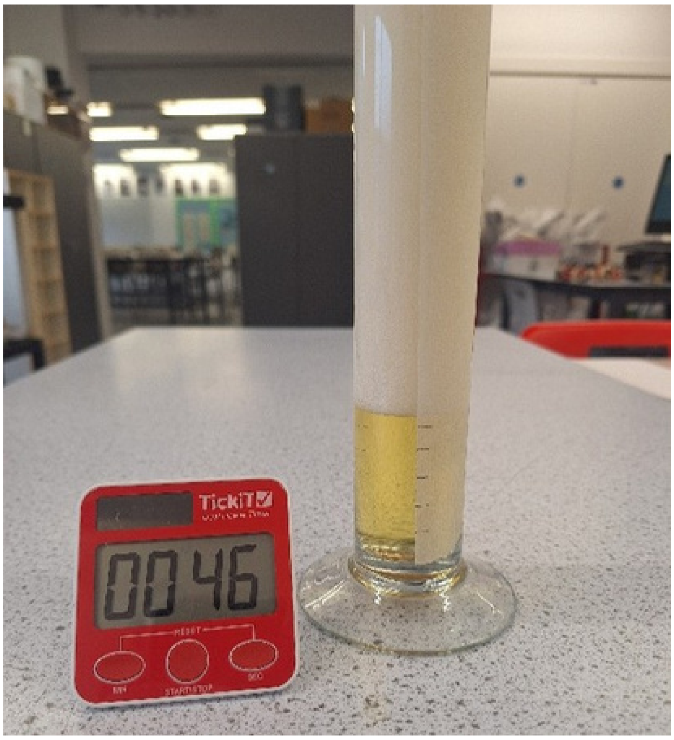

Figure 4. Modelling the half life using carbonated drink foam.

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