Nuclear > Radioactivity Turntable Experiment

Recommended year level: 9 – 10 (7 – 12 including options)
Time taken: 90 minutes
Subject: Physics, Nuclear

Intro:

- This project explores the nature of *radioactivity* in its three main forms; alpha particles, beta particles and gamma rays.

Learning Outcomes:

- Students will understand the important role of radioactivity in society (for good and for ill) and the different behaviour and uses of alpha, beta and gamma radiation.
- These outcomes are achieved through a remote experiment which monitors radiation from alpha, beta and gamma sources and through stories and anecdotes.

Experiment Summary:

- Students will remotely access a Geiger counter which records radioactive emissions from one of four radioactive sources; alpha, beta, gamma and an unknown source to be determined.
- By inserting “absorbers” or barriers made of various materials between the radioactive source and the Geiger counter, students explore the penetrating power of the various sources and the stopping power of the different absorbers.

Expected Results:

- Alpha radiation is very easily stopped by any kind of barrier. It is NOT penetrating.
- Beta radiation is MODERATELY penetrating. It is very sensitive to the THICKNESS of the barrier. This is observed by using different absorber thicknesses of Aluminium.
- Gamma radiation is VERY penetrating and goes through just about anything.
- The unknown source is an alpha source, taken from a smoke detector. This should be apparent to students due to its lack of penetrating power.

Answers to Evaluate Questions:

1. Gamma radiation is the most difficult to contain. Because it is a light ray (not a particle) and has a very small wavelength (much smaller than visible light) it is able to pass through barriers quite easily.
2. Alpha radiation is the easiest to contain. Alpha particles find it very difficult to get through barriers because they are large and heavy and tend to collide with the molecules in the barrier material.
3. Penetration of beta radiation is very sensitive to the thickness of the barrier, particular Aluminium. Increasing the thickness of the Aluminium container wall will reduce the radiation emitted.
4. The unknown sample is Alpha. It has the same characteristics as the "Alpha" source; that is, it is very easily stopped by any sort of barrier.

5. Alpha is the safest radioactive material to handle because it does not readily penetrate the skin and is easy to contain with a barrier.
6. Gamma rays can be used in radiation therapy to treat cancer patients.
7. The smoke enters the smoke detector through the little vents in the casing. Inside the smoke detector there is a radiation detector and an alpha source with a small gap between them. When smokes gets into this gap it acts like a barrier and reduces the number of counts measured by the detector. This sets of the alarm.

Detailed Explanation:

- Alpha radiation is made up of He^{2+} (Helium) nuclei, consisting of 2 protons and 2 neutrons. These are quite large particles and struggle to pass through the spaces between the atoms/molecules of the absorber material.
- Beta radiation is made up of electrons (and sometimes positrons). These are much much smaller and less massive than alpha particles (roughly 10,000 times less massive) and hence can pass through the spaces in the absorber material more easily.
- Gamma radiation (or Gamma rays) is light with a very short wavelength. The wavelength of gamma radiation is of the order of picometers (10^{-12} m). This is roughly 100 times less than the diameter of an atom (around 10^{-10} m). In addition, being uncharged and having no mass, gamma rays do not interact as readily with matter as the particles do. They easily pass through all but a very large thickness of the most dense materials, such as lead.

Technical notes on the experiment:

- Note, that the absolute value of the count rate of a source with Absorber NONE is not really important; all that matters in this experiment is the *change* in counts when the absorbers *are* used. The basic count rate with no absorber present for different sets of apparatus and different sources will vary greatly. This can sometimes be confusing for the students.
- There may be a delay of a couple of seconds when switching absorbers before the count rate stabilises.
- Quickly switching between absorbers may cause the detector to become temporarily misaligned and not line up with anything. Returning to Absorber NONE, then reselecting the desired source, then the desired absorber, will fix this.