FARLab Radioactivity Lab Notes

Warning! Warning!

Radioactivity in society

Say the word "radioactive" and most people think of nuclear-reactor disasters, nuclear waste or the nuclear "fallout" from nuclear wars. You may have heard of the Fukushima disaster in Japan in 2011 in which an earthquake triggered a tsunami that seriously damaged the Fukushima Daiichi Nuclear Power Plant. The damage was so extensive that radioactive material leaked from the nuclear reactor.

What you may not know however, is that radioactivity was discovered over 100 years ago by Marie Curie and her husband Pierre, who discovered that something was being emitted by certain materials; a new kind of energy! Their discoveries created a huge amount of excitement at the time as it was believed that such a powerful new source of energy must be very beneficial.

"One of our joys was to go into our workroom at night ... It was really a lovely sight and one always new to us. The glowing tubes looked like faint, fairy lights." – Marie Curie.

In 1903 Pierre Curie tied a chunk of radium (a highly radioactive material) to his arm for 10 hours. After seeing the severe burns left behind he decided that he had discovered a cure for cancer when all he had done was damage his skin.

For many years after Marie Curie's discovery, a range of dangerous and ridiculous radioactive products were sold to the public - everything from "re-invigorating" Radium water to toothpaste that had Thorium in it; both of which are highly radioactive. The scary thing was that since people didn't know how dangerous they were, companies claimed using them would make you healthier when in reality they were dangerous and could cause cancer.

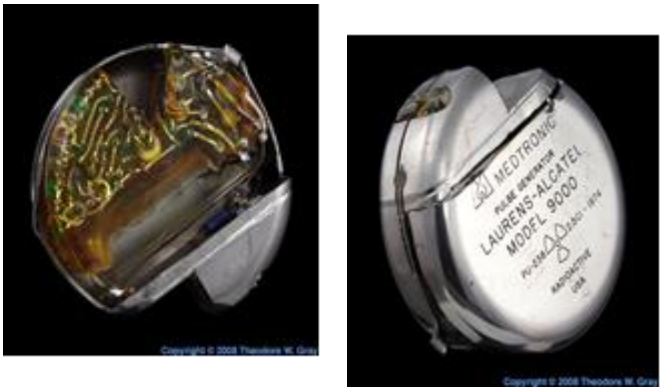
Picture of Radium Drinking solution and radioactive toothpaste-products that contained radium from 1910-1950.

Over time people learned that radioactive materials can be very dangerous and there are many examples of people mis-using radioactive material with terrible consequences. When they are handled correctly, however, we can protect ourselves against their harmful radiation and they can be quite useful.

Plutonium powered pacemakers.

Radioactivity has many beneficial uses:

- in medicine, to destroy cancer cells;
- sterilisation of surgical instruments in hospitals;
- Carbon dating (a method of finding the age of really old things like dinosaur bones);
- to kill germs in your food and
- in smoke detectors.



Plutonium powered pacemakers. An example of radioactivity used beneficially.

Did you know?

- Marie Curie's lab notes cannot be touched for several thousand years because they are so radioactive!

- Marie Curie was the first woman to win a Nobel Prize for discovering radioactivity in 1903. Unfortunately she did not know how to safely handle it and died of radiation poisoning.

In this remote laboratory experiment you will investigate real samples of different radioactive elements called Americium, Strontium and Cobalt. We will do this to better understand how we can protect ourselves against the harmful radiation from these different radioactive sources.

What is radioactivity?

- Most of the elements you know from the periodic table are in their "stable" form.
- But most elements also have "unstable" forms.
- The unstable forms are constantly trying to return to a more stable form by discharging particles and energy from inside themselves.
- These discharges are called "radiation" which you will try to detect in this remote experiment.
- Radiation comes in three different forms that we call "alpha", "beta" and "gamma" radiation.

In this FAR Lab experiment you will monitor the radiation from four real radioactive samples; an alpha source, a beta source, a gamma source and an unknown source.

Logging on using the FARLabs website:

- On the FAR Labs home page, click on the "Nuclear" button.
- It will open up a page with three tabs ("Turntable", "Inverse-square Law" and "Half-Life") on the left side of the page.
- Make sure the "Turntable" tab is open and click on the "Explore" button.
- You should see five big green buttons on the left side. Click on the number your teacher has given you.

- This will open your workstation. Login with your student password and you are ready to begin!
- Clicking the buttons labelled "Source" lines up the detector (called a Geiger counter) with one of four real radioactive samples.
- Clicking the buttons labelled "Absorber" puts a barrier made of a particular material in between the source and the detector.

Three very different kinds of radiation come from radioactive materials: - "alpha", "beta" and "gamma". A radioactive sample of each type can be selected, as well as an "unknown" radiation type which you will try to determine.

We are also interested in how the barriers affect the radiation. That is, which barriers can the different types of radiation pass through and which barriers are they unable to pass through. All radioactive emissions are potentially very harmful to humans so it's important to know this.

PART 1: Alpha Radiation

Method:

1. In the column with the Source buttons, click on the “Alpha” source and in the Absorber column, click on “None”.
2. Make at least five recordings of the counts and make a note in your lab books OR
3. Wait for your Count History graph to record at least 30 seconds of data then create a PNG image.
4. Repeat this process for the Plastic, Thin Aluminium, Thick Aluminium and the Lead barrier (be sure to leave some time for the graph to stabilise after you change your Absorber).
5. Find the *average* number of counts for each barrier by averaging your recordings of the counts OR by ruling a horizontal line on your saved plot that runs through the middle of the points.

Question:

1. What did you notice when you went from no barrier to a barrier?

You may notice that alpha radiation doesn't penetrate barriers much at all. In fact, it turns out that even our skin is enough to stop most alpha radiation. The only way alpha radiation can do damage to humans is if it is inside our body.

The poisoning of Alexander Litvinenko

Alexander Litvinenko was an ex-Russian KGB officer (a spy) working for the British Government who suddenly fell ill under suspicious circumstances. Initial symptoms were of poisoning then he lost all his hair and died in hospital three weeks later. An autopsy revealed large amounts of a radioactive material in his system. Also, a suspicious trail of radiation was detected wherever Litvinenko had been in the days before being admitted to hospital. It turned out he had been poisoned with a radioactive alpha source called Polonium. It was used because it is safe for the killers to handle, but is lethal when ingested.

Alexander Litvinenko on his death bed

PART 2: Beta Radiation

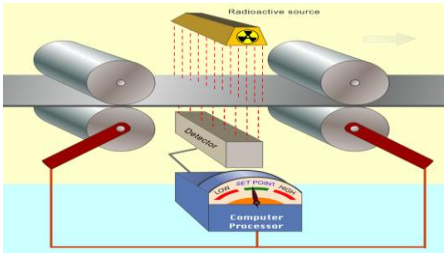
Method:

6. Select the Beta source and Absorber None.
7. Repeat steps 2-5 that you did for the Alpha source.

Question:

2. What do you notice when you go from no barrier to the different kinds of barriers? Was there a difference between the thin and thick piece of Aluminium?

Nuclear reactors are great for generating power but they also generate a lot of radioactive waste materials which needs to be disposed of.



Using beta radiation to determine the thickness of Aluminium sheets during manufacture.

Radioactive beta material can be safely stored as long as the walls of the container are made thick enough to prevent radiation from escaping. It can also be used to determine the thickness of Aluminium sheets during manufacture by keeping the number of counts at a constant number.

PART 3: Gamma Radiation

Method:

8. Select the Gamma source and Absorber None.
9. Again, Repeat steps 2-5 that you did for the Alpha source.

Question:

3. Does anything affect the average number of counts for gamma radiation? If so, how?

Gamma radiation has such a high penetrating power you need a very thick barrier to stop it.

A woman being treated for breast cancer with chemotherapy.

Gamma radiation is particularly damaging to humans. It can cause cancer and other sickness. The irony is that gamma radiation can also be used to kill cancer cells in cancer patients. This is called chemotherapy.

Test your knowledge:

1. Which kind of radiation is the most difficult to contain? Why?
2. Which kind of radiation is the easiest to contain? Why?
3. If you discovered that an Aluminium container of radioactive beta material was still emitting radiation, how could you reduce the radiation emitted?
4. What do you think the unknown sample is? Alpha, beta or gamma? Can you explain why?
5. Which is the safest kind of radioactive material to handle and why?
6. Gamma radiation is particularly nasty, but can you describe a beneficial use?
7. The unknown sample has been taken from a smoke detector, where there is a radioactive sample a short distance from a radiation detector, which is open to the air. How does a smoke detector work?

Further Discussion (Optional):

Australia has long been discussing the possibility of creating a nuclear waste dump in the outback somewhere. What do you think about this idea? What are the issues that would need to be considered before saying yes or no?

Here are some quick links to help you form an opinion:

http://www.abc.net.au/radionational/programs/ockhamsrazor/nuclear-waste-disposal-in-australia/4561412

http://www.independentaustralia.net/2011/politics/australia-open-for-nuclear-sewage-business/