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Physics 132- Lab Section 24

Radioactivity

Abstract:

In this lab we studied radioactivity. It is understood that a nucleus of an atom with an excess of neutrons or protons is unstable and will undergo radioactive decay. There are three particles that are emitted from radioactive atoms undergoing decay, which are alpha (α), beta (ß), and gamma (γ) particles. An important concept in this experiment is the half-life (T1/2), which is the time it takes for half of the initial amount of nuclei to decay. To measure radioactivity we used a device called a Geiger counter which detects radiation produced by ionization in low pressure gas.

Post-Lab Questions:

1.

Count	Time (min)	Counts/Min	Statistical Range
86	**5**	**17.2**	**13.06 – 21.34** (17.2 +/- 4.14)

Trial	**Counts/Min**	**In range?**
1	15	Yes
2	9	No
3	10	No
4	18	Yes
5	13	No
6	13	No
7	22	Yes
8	15	Yes
9	14	Yes
10	13	No

Source	**Radiation**	**Absorber**	**Counts/Min**
Polonium	α	Nothing	55
	α	Cardstock	34
Strontium-90	ß	Nothing	7754
	ß	Thin Aluminum	46
Cobalt-60	γ	Nothing	2287
	γ	Thick Aluminum	2136
	γ	Lead	1439

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2. According to our results, gamma rays have the most penetrating power. If the radioactive source is outside the body, these rays would be considered the most dangerous, because they can penetrate through living tissue, damaging the cells inside, even from relatively far distances. However, if the radioactive source is inside the body (ingested or inhaled), alpha radiation would be considered the most dangerous, due to the fact that it is easily absorbed by cells and can cause significant biological damage, whereas beta and gamma radiation would simply pass right through.

3. $T_{½} = -\ln 2/m$ (m = slope of In-116 = -1.891×10^{-4})
   $T_{½} = -\ln(2)/-1.891 \times 10^{-4} = 3665.5$ seconds = **61 minutes**

4. $N = N_0 e^{-mt}$
   $t = t_{½} / \ln 2 = (150 \text{ min}) / (0.693) = 216.4$ minutes
   $N_{30} = (2.3 \times 10^{10} \text{ atoms})(e^{-30min/216.4min}) = 2 \times 10^{10}$ atoms
   $N_{160} = (2.3 \times 10^{10} \text{ atoms})(e^{-160min/216.4min}) = 1.10 \times 10^{10}$ atoms
   $(2 \times 10^{10} \text{ atoms}) - (1.1 \times 10^{10} \text{ atoms}) =$ **9×10^9 alpha particles**

5. **Reaction expressions**:
   α =

   ß =

   γ =

- *Alpha particles* are equivalent to a helium nucleus, and are radiated from elements with large atomic numbers (Z), such as uranium. Since the alpha particle has two protons and two neutrons, the daughter element will lose two of each particle as well (known as a nucleon). These particles have large amounts of kinetic energy, and can cause many ionizations to occur, making them hazardous within small distances from the element
- *Beta decay* is the most common form of radioactivity and comes in two types: a very energetic electron, and a less common positron, also known as the

"antiparticle" of the electron. These emissions maintain the charge of the original element (neutrons become protons, protons become neutrons, respectively).

- *Gamma decay* is a type of electromagnetic radiation in which protons (the gamma particle) behave like continuous waves. These particles are emitted when highly energetic nuclei 'drop' from an excited state to a lower energy state. These particles have very high penetration rates and are potentially hazardous to living organisms, due to their long emission lengths.

6. **X-rays**

   Similar to gamma rays, in that X-rays can penetrate tissues easily, travel long distances, and are a form of electromagnetic radiation. These rays "go through" the skin and soft tissue, but not through harder tissues such as bone. Thus, bones can be portrayed on a screen so that one may be able to examine abnormalities or fractures.

   Microwave Oven

   Less powerful than x-rays, microwaves fall into the radio frequency band of electromagnetic radiation. Microwaves are produced inside the oven by an electron tube known as a magnetron, which are reflected within the metal interior and are then absorbed by the food. This causes water molecules in the food to vibrate, thus producing heat that cooks the food.

Conclusion:

Completion of this experiment has allowed us to effectively gain a better understanding of radioactivity at the molecular level. Using the given slope of -1.891×10^{-4}, we calculated the half life of Indium-116 to be approximately 61 minutes, which is relatively close to the actual half-life of 54 minutes. The next part of this experiment required us to measure radiation that exists everywhere in the environment (or background radiation) for five minutes, resulting in a count of 17.2 +/- 4.14 counts per minute as our statistical range. After recording counts per minute for ten trials, our counts per minute revealed that exactly half of our trials remained within the confidence interval. Next, we recorded radioactivity of Polonium, Strontium-90 and Cobalt 60, corresponding to either alpha, beta or gamma radiation. Aluminum and lead were used as radioactive blockers by placing the sheets between the elements and the Geiger counter. After seven trials, Gamma radiation was found to be the most penetrative of the three, traveling a significant amount through both thick aluminum and lead sheets.