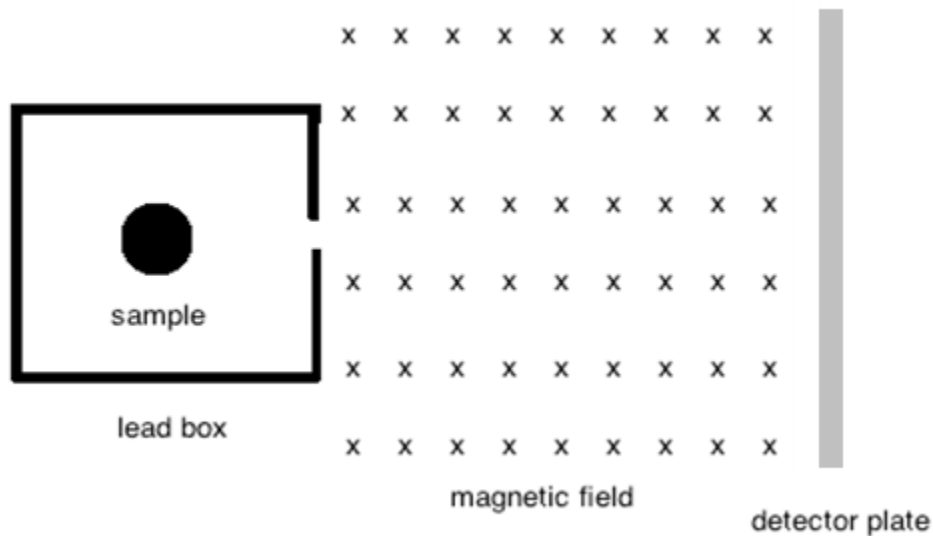


Radioactivity

In your own words, and without looking anything up, discuss or define radiation or radioactive decay. Write your definition/discussion in your lab notebook.

In 1896, Becquerel discovered that uranium salts could darken a photographic plate, even if the photographic plates were completely covered to exclude light. He concluded that the uranium was spontaneously emitting radiation (energetic particles or waves). Through further work by Marie and Pierre Curie and Ernest Rutherford, it was determined that uranium and other elements have unstable nuclei that spontaneously decay, emitting alpha particles, electrons or positrons, or gamma rays. Alpha particles are Helium nuclei, consisting of two protons and two neutrons. Positrons are identical to electrons, but with positive charge. Gamma rays are high frequency electromagnetic waves.

- 1) Suppose three kinds of radiation were emitted from a sample in a lead box. Some of the emitted particles or waves escape through a hole in the box into a magnetic field into the page (as in the picture below).



Sketch the path of

- a) an alpha particle
- b) an electron
- c) a gamma rays

Discuss why you drew the path the way you did.

How could this be used to determine the type of radiation? Sketch the path of a positron on the same diagram. How could you distinguish the positron's path from the electrons path? From the alpha particles path? Explain.

- 2) This is a prediction. Predict if any of the types of radiation could pass through different types of barriers. Consider three kinds of barriers: a) a sheet of paper, b) a few millimeters of aluminum, a few centimeters of lead.
- 3) The decay process is probabilistic in nature. One cannot predict whether a particular atom will decay or not, but we can predict how many will decay on average within a given time period. This is the rate of decay. Given some number N of a radioactive isotope, we expect that the number of decay events dN in some time dt should be proportional to the number of isotopes present. So, the rate of decay is

$$dN/dt = -\lambda N$$

where λ is a proportionality constant.

This is a first order differential equation that can be solved for $N(t)$, the number of undecayed radioactive nuclei as a function of time. Let the number of undecayed nuclei at time $t = 0$ be N_0 and solve this equation for $N(t)$. Show and discuss your solution with the teaching assistant (TA).

The constant λ is often written as $\lambda = 1/\tau$, where τ is the mean lifetime. Discuss the mean lifetime in terms of how many nuclei have decayed at time $t = \tau$.

- 4) The half-life of a radioactive sample is the amount of time it takes for $1/2$ of the nuclei to decay. Calculate the half-life of a sample in terms of λ .

Work the lab.