INVESTIGATION 2

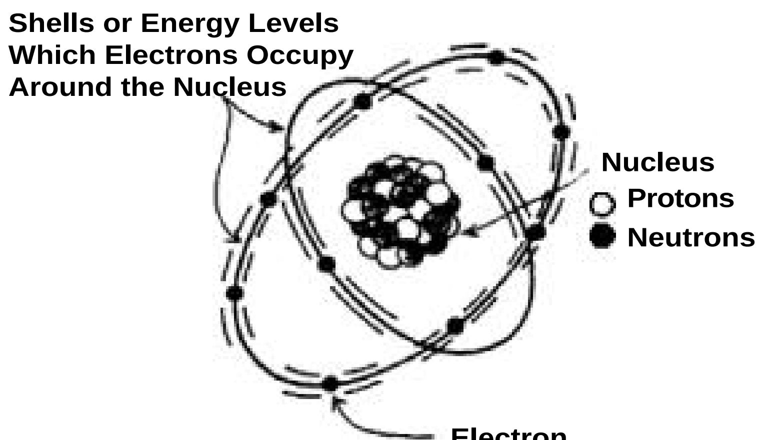
HOW DOES PROBABILITY RELATE TO RADON?

INTRODUCTION

Although we seldom think about it, we deal with probability every day. What are the chances that I will oversleep and miss the school bus if I don't set my alarm? What is the probability that I will win the coin flip with my sister to determine who picks the movie we are going to watch? Probability theory allows us to make predictions about different things such as birth, death, and accident rates, and in the case of today's topic, the breakdown of nuclei during the radioactive decay process.

Radioactivity is a fascinating and complicated process that illustrates probability. Radioactive materials emit their radiation on a certain time scale, but within that time scale the emissions occur at random. For example, a radioactive material might emit radiation "on average" ten times per second. If you measure the emissions during any one second, however, you might measure 5 or 20. It won't always be 10. During this radioactive "decay" process, the element spontaneously gives off particles or bits of pure energy, known as radiation.

Radioactivity - the spontaneous emission of energy from the nucleus of certain (radioactive) atoms, resulting in a change from one element to another. The energy can be in the form of alpha or beta particles and gamma rays.



A model of an atom.

Three types of radiation can be given off when a radioactive material decays: alpha, beta, gamma. Some differences between these radiation types are illustrated in Figure 1. The rate at which the decay process takes place is fixed and constant for each kind of radioactive element. The time it takes for one-half of the atoms in a radioactive element to decay is called the half-life of that isotope. Each radioactive isotope has its own unique half-life, which is unaffected by temperature, pressure, and other factors. During the decay process, one element, or isotope, changes into another, and radiation is given off in the process. **In this exercise, you will conduct an investigation that simulates radioactive half-life and its relationship to probability.**

Isotopes - two or more forms of the same element which have the same number of protons, but a different number of neutrons in their nuclei.

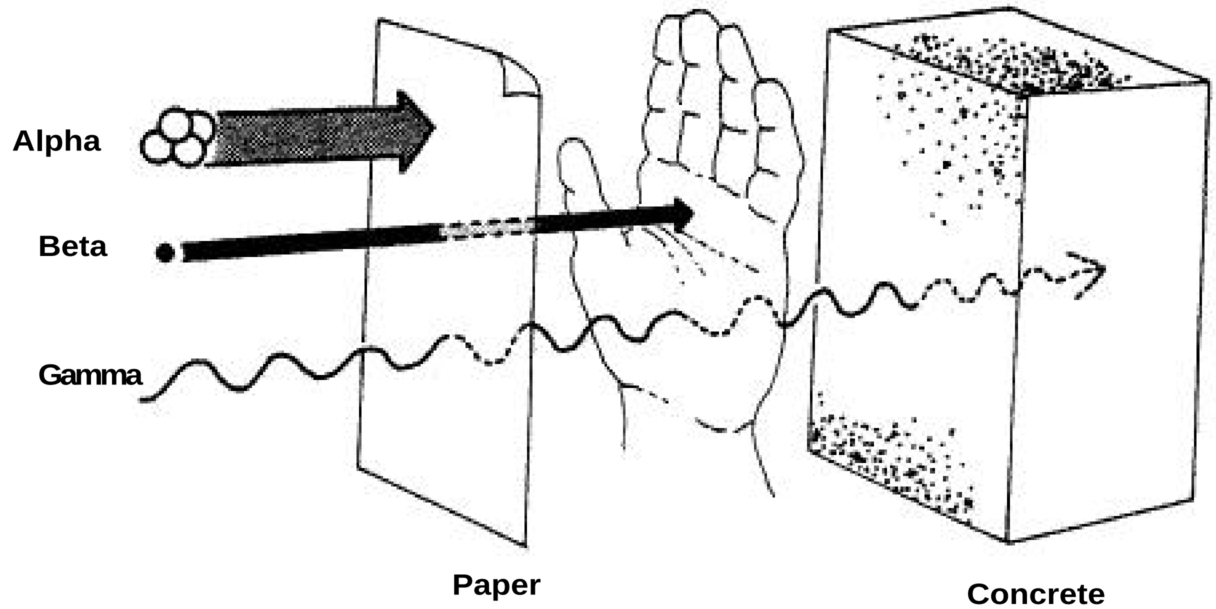


Figure 1. Penetrating power of radiation. Alpha particles are relatively large, but are easily stopped by a piece of paper or a layer of skin. Beta particles are much smaller, travel at high speed, and can penetrate the skin. Gamma radiation has no mass, travels at the speed of light, and can go right through the body.

OBJECTIVE

To apply the process of probability to the concepts of radioactive decay and radioactive half-life.

MATERIALS

• One large bag of m&m's (plain)

PROCEDURE

Note: Each m&m in the bag represents a radioactive atom. An atom decays and emits its radioactivity when the side marked "m" turns up. It is removed from the pile before the next roll.

1. Begin by rolling all m&m's (atoms). You may eat some, but be sure to begin with at least 100 atoms. Eat the yellow ones; it is hard to see the "m" on them! Remove any atoms that decay (the side marked "m" turns up). Record your results in table format.

2. Continue rolling all active atoms until all of them have decayed.

3. Do you think the results would be exactly the same if you rolled the radioactive atoms again? Why or why not?

DATA COLLECTION

4. Make at least five trials, each time starting with a full bag of radioactive atoms. As in Step 1, roll all radioactive atoms until they have all decayed.

5. Enter the data from your experiment on a separate sheet of paper for each of the five trials.

6. Plot an X/Y graph of your data, using the format shown below.

Note: The half-life of a radioactive substance is the time it takes for half of the atoms to decay.

Example format for entering m&m data:

Roll Number	Number of radioactive atoms remaining at beginning of roll					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Approximate number of rolls needed to remove half of atoms						
Approximate number of rolls needed to remove all of atom						

ANALYSIS

7. How many rolls were necessary (on average) before half of the atoms decayed?
Note: Each roll represents one half-life for your m&m's.

8. How many half-lives were necessary (on average) before 3/4 of the atoms decayed?

Why do you think you obtained this result? What does your result tell you about the definition of half-life?

9. How many *additional* rolls do you think it would take to deplete the pile if your starting pile was twice as large?

10. Perform several trials to check your prediction.

11. If the half-life of your m&m atom was 1 year, about how long would you have to wait before it all decayed away? Why?

12. You are given 10 grams of pure uranium-238 on January 1. Its half-life is 4 1/2 billionyears, and it decays to form thorium-234.

a) How long would you have to wait before half of it turned into thorium-234?

b) How much would you have left after 9 billion years?

CONCLUSIONS

13. What have you learned about radioactivity that you did not know before class?

14. Why is half-life an important characteristic of a radioactive isotope?

NOTES