INVESTIGATION 2

WHAT IS RADIOACTIVITY?

INTRODUCTION

The study of probability allows us to make predictions about the occurrence of certain events such as birth, death, and accident rates, and in this case, the breakdown of atomic nuclei during the radioactive decay process. Radioactivity is emitted when particles or energy rays are given off by an atom's nucleus (See Figure 1). Three different kinds of radiation can be given off: alpha, beta, or gamma (Figure 2). During this “decay” process, the element spontaneously gives off particles or energy rays, known as radiation. Radon-222 is the direct product of the decay of the most common radium isotope, radium-226. Radium is a product, several steps removed, of the decay of the most abundant uranium isotope, uranium-238. down into its decay product isotopes, polonium-218, among others. Decay product isotopes are sometimes referred to as progeny or daughters.

Each element has a characteristic average rate of decay that doesn't change. The time it takes for one-half of the atoms in a given radioactive sample to decay is called the half-life of that isotope. Each radioactive isotope has its own unique half-life, which is totally unaffected by temperature, pressure, and other factors. **In this exercise you will conduct an investigation that simulates radioactive half-life and its relationship to statistical probability.**

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)

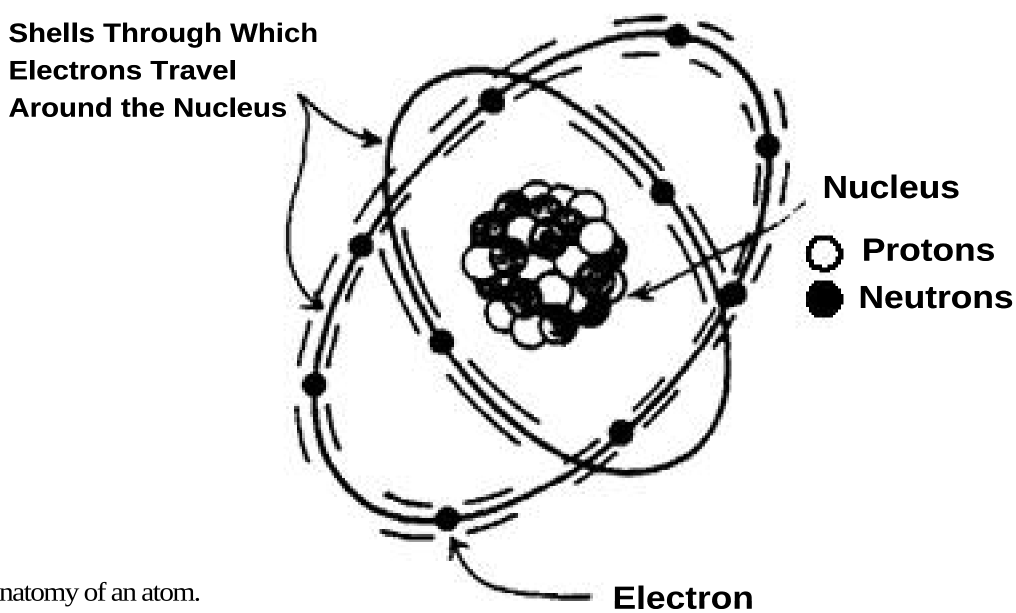


Figure 1. Anatomy of an atom.

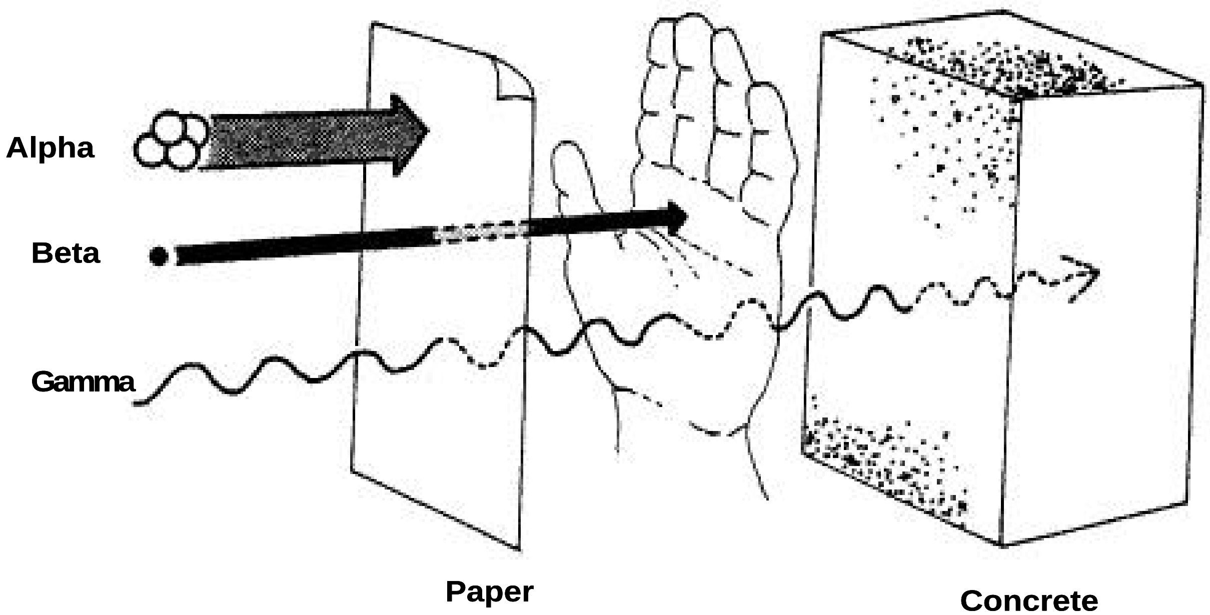


Figure 2. Penetrating power of radiation. Alpha particles are relatively large, but are easily stopped by a piece of paper or a layer of skin. Beta particles are much smaller, travel at high speed, and can penetrate the skin. Gamma radiation has no mass, travels at the speed of light, and can go right through the body.

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 the procedure 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 the radioactive atoms repeatedly until they have all decayed into a new isotope.

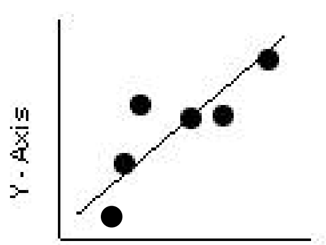
5. Collect the data from your experiment for each of the five trials.

6. Plot an X/Y graph of your data, using the Graph option from the LabQuest Spreadsheet. If the LabQuest software is not available, you can plot the data by hand.

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

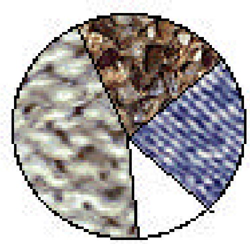
EXAMPLE GRAPH

LINE GRAPH

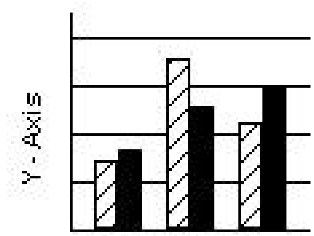


X - Axis

PIE CHART GRAPH



BAR GRAPH



X - Axis

In a line graph, data points are plotted on the graph and then connected by a line. The line can either connect each point to the next or approximate the pattern displayed by the data points, as shown above. In a bar graph, the height of each bar corresponds to the values on the y-axis. Bar graphs and pie charts are good when you want to combine a lot of data points into different categories. Each category will then be displayed as one bar or one slice of the pie.

The following guidelines will help you to draw clear, easily-interpreted graphs:

1. Determine which set of numbers will be shown on which axis. If you think that one variable (set of numbers) might be causing the other variable to be affected, then it is best to put the variable suspected of causing the effect on the x-axis (horizontal) and the affected variable on the y-axis (vertical).

2. Choose scales for each axis. They don't have to be the same. They don't have to start at zero, and sometimes can include negative numbers. Choose scales that allow you to clearly show all of your data points without having a lot of empty space.

3. Number the major divisions along each axis, label each axis, and show when possible the units used.

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?

____

Explain why you obtained this result, in terms of 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. You are given 10 grams of pure uranium-238 on January 1. Its half-life is 4 1/2 billion years, 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? ________________

c) How long would you have to wait before you had only 1/2 g left?
Hint: Use graphing techniques to approximate the length of time.

____

CONCLUSIONS

12. In your own words, explain the half-life of an element.

____

____

____

13. Why do you think half-life is an important concept in the study of radon?

____

____

____

____

____