HALF-LIFE SIMULATION WITH M&MS

LAB NR 7

INTRODUCTION

Half-life, $t_{1/2}$, is the time required for the number of radioactive nuclei in a sample to drop to one-half the initial value. For example, the half-life of phosphorus-32, a radioisotope used in leukemia therapy, is 14.28 days. If today you have 1.000 grams of phosphorus-32, 14.28 days from now only 0.500 grams of phosphorus-32 will be left because one-half of the sample will have decayed by beta emission, yielding 0.500 grams of sulfur-32. After another 14.28 days have passed, only 0.250 grams of phosphorus-32 will remain, and so on. Each passage of a half-life causes the decay of one-half of whatever sample remains.

The half-life of a radioisotope is a constant - no matter the size of the sample, the temperature or any other external conditions. There is no way to speed up or slow down this natural process. Half-lives range from fractions of a second to billions of years. Radioisotopes used internally in medical applications have fairly short half-lives so that they decay rapidly and cause no long term health hazards.

PURPOSE

The purpose of this experiment is to simulate the process of radioactive decay and determine the "half-life" for the process.

SAFETY

Consideration must be given to cleanliness and dietary issues, such as diebetics.

MATERIALS

plastic sandwich bag of M&Ms
paper plate

PROCEDURE

Each M & M will represent at atom of a radioisotope. The M & Ms in the baggie are thoroughly mixed and poured out onto the paper plate. Those M & Ms <u>with</u> letters showing are still "radioactive". The others have "decayed" and should be removed. Count the numbers of "atoms" removed and record the values in the data table. Return those M & Ms which have the letters showing to the bag, shake, and pour onto the paper plate. Again, count the number of M & Ms with no letters showing. Record and continue. When the data has been collected, plot the data (atoms left vs. trial number) and draw a smooth curve through the points.

The value for the half-life is obtained as follows:

1. Select two values on the y-axis. One value should be twice as large as the other (60 & 30 for example).

2. Draw lines from these points to your line.

3. Next, vertical lines should be drawn from where these lines intersect your lines to the x-axis. The space between these lines on the x-axis is the half-life. What these lines tell us is that half of the radioisotope has decayed and this is the amount of time that is required for it to happen.

DATA SHEET

Name ________________________

Name ________________________

Period _______ Class ___________

Date ___________

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DATA TABLE

Original Number of Atoms _______________

Trial	Atoms Decayed	Atoms Left
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

ANALYSIS

1. Write a balanced nuclear equation for beta emission from phosphorus-32.

2. Use your graph and the definition of half-life to determine the half-life of the "M&M" radioisotope. Show your work on your graph.

3. The decay constant, k, for a radioisotope is related to its half-life:

   $$k = 0.693 / t_{1/2}$$

   Use this relationship to determine the decay constant for the M&Ms.

4. The equation in question 2 can be obtained from the integrated rate law

   $$\ln (N/N_0) = -kt$$

   where N_0 is the number of radioactive nuclei originally present in the sample and N is the number remaining at time t. Show how this is done.

5. How long (many turns) would it take to comlete this simulation - until 1 M&M remains - if you had started with 10,000 M&Ms? Show your work.

CONCLUSION (2-3 sentences)