**Half-Life Simulation**

**Introduction**
Radioactive decay is a spontaneous and completely random process. There is no way to predict how long it will take a specific atom of radioactive isotope to disintegrate and produce a new atom. The probability, however, that a specific atom will decay after a certain period of time can be simulated by studying other random processes, such as a coin toss or a “roll of the dice”.

**Background**
Radioactive nuclei disintegrate via different processes and at different rates. The amount of time required for different radioactive nuclei to decompose varies widely. Very unstable nuclei decompose in seconds or minutes; long-lived radioactive nuclei may be around for to a billion years or more.

For example, Polonium-218 emits alpha particles and decays very quickly—within minutes. Uranium-238 also emits alpha particles and decays, but its decay takes place over billions of years.

The relative rate of decay of different radioactive isotopes is most easily described by comparing their half-lives. The half-life ($t_{1/2}$) of a radioactive isotope is the amount of time needed for one-half of the atoms in a sample to decay.

Every radioisotope has a characteristic half-life which is independent of the total number of atoms in the sample. The half-life of Po-218 is about three minutes. That means that one-half of the atoms in a sample of Po-218 will decompose to produce other atoms within three minutes. Every 3 minutes, the amount of Po-218 that remains will decrease by 50%. *(NOTE: The half-life of U-238 is more than 4 billion years.)* The initial sample is considered the parent isotope; the atoms that are created through the radioactive decay are the daughter isotopes.

**EXAMPLE:** Iodine-131 has a half-life of eight days. If you start with 32g of I-131, how much will you have after...

...8 days? ____________

...16 days? ____________

...24 days? ____________

If you start with 100g of I-131, how long will it take until you only have 6.125g left?

___________
Pre-Lab Questions
Strontium-90 is a radioactive isotope with a half-life of 29 years. Assume that 10,000 atoms of Sr-90 are generated in a nuclear reaction and then stored.

Complete the following table to determine how much time will have elapsed when 1250 atoms of Sr-90 remain in the storage facility.

<table>
<thead>
<tr>
<th>Number of half-lives</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Sr-90 atoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure
1) Count 120 pennies and lay them heads up in the bottom of a shoe box. This is 0 daughter atoms and 120 parent “pennium” atoms at time 0.
2) Put the lid on the shoe box and, holding the lid on tightly, shake the box with moderate force up and down 20 times while your lab partner times the decay process to the nearest second. Assume that all the subsequent decay trial times are identical.
3) Open the box and count the tails-up pennies, which represent the daughter atoms, and remove them from the box. Subtract this number from the original number of heads-up pennies to determine the number of remaining parent pennium atoms. Record the time taken for the shaking, the number of tails-up atoms removed, and the number of remaining parent atoms.
4) Repeat steps 2 and 3 four more times (for a total of 5 rounds), recording your data after each trial. Add on the original shaking time repeatedly to arrive at the total elapsed time.
<table>
<thead>
<tr>
<th>Round #</th>
<th>Total Elapsed Time</th>
<th>Number of Daughter Atoms Removed</th>
<th>Number of Parent Atoms Remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions
1) Make a graph of your data, plotting the number of remaining parent pennies on the y-axis and the total elapsed time on the x-axis.

2) What is the half-life of pennium in your experiment? ______________________
   How did you arrive at that number?

   How many rounds are needed for one-half of the pennium to decay? _________

3) Using the value of the half-life determined in question #2, predict how many pennies should have remained after 6 rounds (HINT: it’s OK to predict a fraction of a penny)

4) Using the concept of half-life, predict the number of rounds that would be needed to reduce the number of pennies from 10,000 to 625.

5) Does exactly the same fraction of pennium atoms decay during each half-life? ________________
   What does this suggest about half-life?

6) If you took a longer time to shake the box, how would half-life be affected?