Half-Life of Pennyium Activity

Purpose: To simulate the transformation of a radioactive isotope over time and to graph the data and relate it to radioactive decay and half-lives. Time will be analogous to trials for our experiment.

Pre-Lab Questions:

1. What are the three main forces that exist in the nucleus of an atom? Which is/are repulsive and which is/are attractive?
2. Why do atoms go through radioactive decay? (Why are nuclei unstable?)
3. What is half-life?

Materials:

- 100 pennies (or M&Ms)
- cup
- graph paper
- 100 paper clips

Procedure:

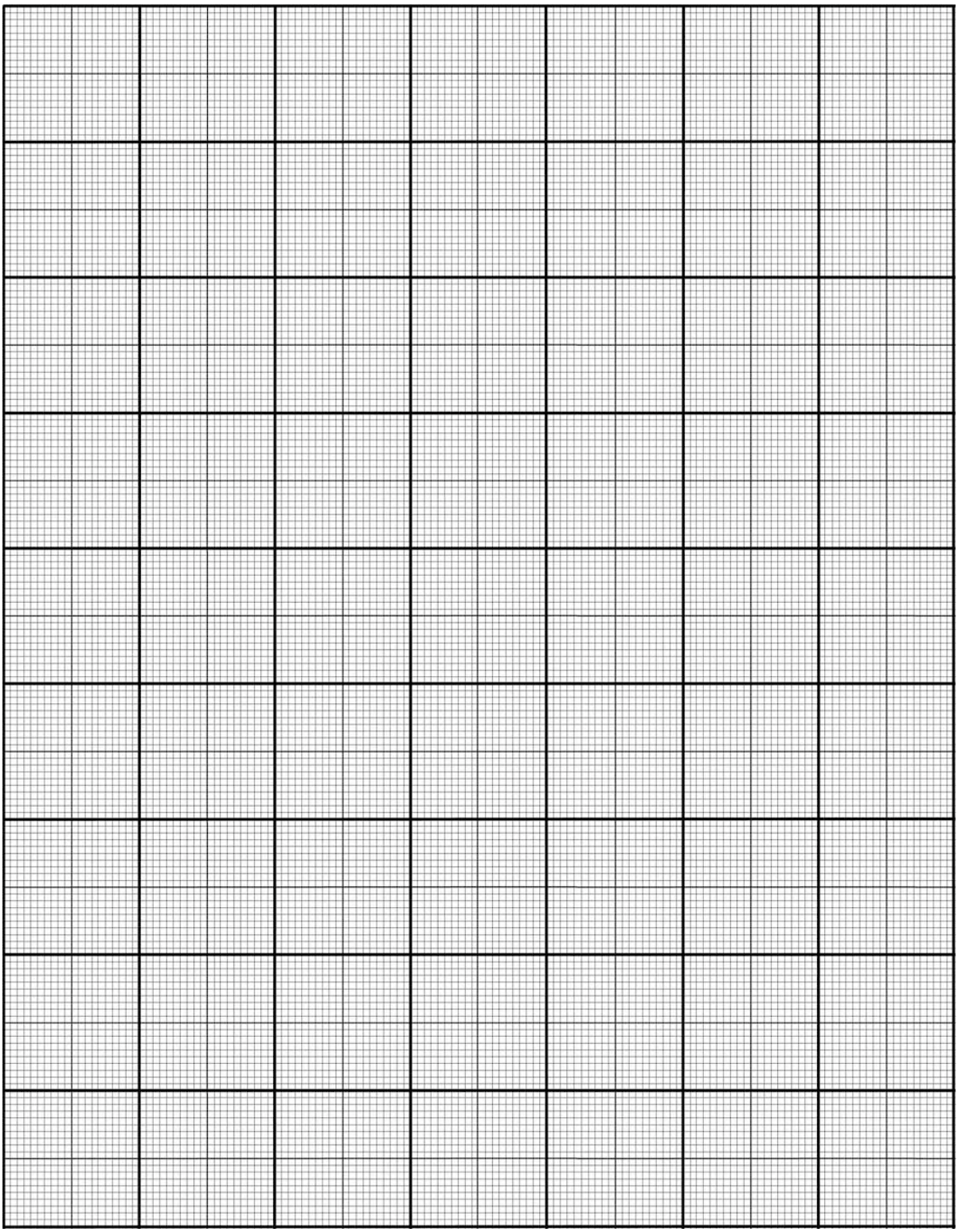
Pour 100 pennies from your cup onto the lab table. In your grid, record the total number of heads that result. These heads represent pennies that have decayed into daughter atoms. Place all of the "tails" pennies back in the cup, and replace the "heads" pennies (pennium decayed isotopes) with the same number of paper clips (Clipium daughter isotopes).[1] Pour the "tails" pennies and clips from your cup onto the lab table. Record the total number of heads that result. Continue this procedure until you obtain no more tails. (% pennies remaining should go from 100% to 0%. It may require more or less than 7 trials)

Trial #	Number of pennies	Number of heads	% pennies remaining
1	100	0	100%
2			
3			
4			
5			
6			
7			

Analysis:

1. Use graph paper to plot the % pennies remaining (y-axis) versus the trial number (x-axis). Draw a smooth line or curve through the points.
2. Examine your graph. Is the rate of the number of heads produced over time linear on nonlinear? Is the rate constant over time or does it vary over time?
3. With another color pen, draw the % pennies that ***are predicted*** to remain after each half- life on your same graph.
4. A half-life is the time required for one-half of the atoms of a radioisotope to emit radiation and to decay to products. For the process of flipping pennies, what do the "heads" pennies and "tails" pennies represent respectively?

[1] In a sample the atoms don't leave a sample leaving space behind, they change into something else. Just as you saw with your alpha, beta decays.



Post-Lab Questions: give a short explanation, or no credit will be given.

1. If 50% of a radioactive element remains after 4000 years, what is the half-life?
2. If 25% of a radioactive element remains after 1,000 years, what is the half-life?
3. The half-life of a certain radioactive element is 1,250 years. What percent of the atoms remain after 7,500 years?
4. The half-life of a certain radioactive element is 800 years. How old is an object if only 12.5% of the radioactive atoms in it remain?

Conclusion: Compare your two plots. How well did the tossing pennies simulate half-lives? Explain.

TEACHER NOTES

Misconception Alert

- **Why add paper clips?** Adding paper clips helps to alleviate the misconception that when decays occur the atoms disappear.
- **Half lives vary among isotopes. "**Trial" is analogous for half life, which can vary from femtoseconds to billions of years. Pennies though the natural statistics will work out to be very close to _, dice would be 1/6 etc…

Possible Extensions/Modifications

- Half life can be taught by using ratios and graph interpolation to avoid the use of logs.

- Collecting the data and plotting the data in Excel, Logger Pro or on graphing calculators to get the equation of the bet fit curve.

- Using money to actually show the types of decay, using cash value and start with quarters or dimes and put back say a nickel and 5 pennies (a new lighter atom and some alpha particles)

- Having quarters decay into nickels, nickels decay into pennies and pennies, and giving each a different "half life" by taking only a portion of the heads or all of the heads and a portion of the tails. This would then simulate longer or shorter half lives.

- To add a kinesthetic component one teacher gives each student a die. Each student stands and rolls the die, if the #6 comes up then the student decays to the back of the room. The data can then be kept on the board in the front of the room.