

In today's activity, you and your group will examine alpha and beta decay using a simulation, as these are things we cannot see in our lab. First, you will investigate alpha decay using the Alpha Decay simulation (<https://phet.colorado.edu/en/simulation/legacy/alpha-decay>).

When the simulator opens, click on Single Atom. The nucleus that will be investigated is polonium-211.

1. How many protons and neutrons does polonium-211 have?

84 protons, 127 neutrons

2. After polonium-211 decays, what stable nucleus is formed?

Lead-207, which has 82 protons and 125 neutrons

3. Does the atomic number change when polonium-211 decays to lead-207? What about the mass number?

The atomic number decreases by 2; the mass number decreases by 4.

▶ If necessary, click on Reset Nucleus to see the simulation again.

4. Pause the simulation immediately after the decay occurs. What does the particle that is emitted from the nucleus consist of?

2 protons, 2 neutrons

5. This particle is called an alpha particle, and is made of two protons and two neutrons. If you knew this before the simulation, could you have predicted the identity of the stable nucleus that is formed?

Yes, the identity of the stable nucleus could be predicted using a radioactive decay equation.

6. What is the half-life of polonium-211?

0.5 seconds

7. Repeat the simulation for a total of 10 times. How many times does polonium-211 decay before the half-life time out of those 10 times?

It should decay roughly 5 out of 10 times.

Next, click on Multiple Atoms in the simulation. Add all 100 polonium-211 nuclei to the simulation by adding 100 nuclei to the simulation at a time under the Bucket o' Polonium. Once you have all 100 added, click on Reset All Nuclei.

8. After you click on Reset All Nuclei, the simulation starts over again. By when do you expect most of the polonium-211 nuclei to decay?

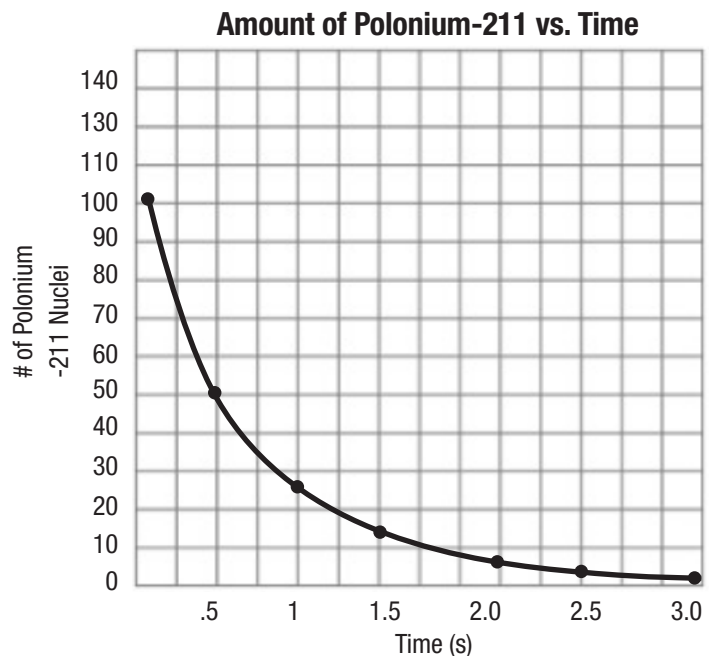
Half of the nuclei should decay by 0.5 seconds, which is the half-life time.

9. Pause the simulation at the half-life marker. In the upper left-hand corner, there is a pie chart and a data table. How many polonium-211 nuclei remain after one half-life? How many lead-207 have been created?

*Roughly half of the polonium-211 should be decayed,
and the amount decayed should turn into lead-207.*

10. Pause the simulator after every 0.5 seconds, and note the number of polonium-211 nuclei present. Fill in the data chart below, and create a graph of polonium-211 nuclei versus time.

Time	# of Polonium-211 Nuclei
0	100
0.5 seconds	~50
1.0 seconds	~25
1.5 seconds	~13
2.0 seconds	~7
2.5 seconds	~4
3.0 seconds	~2



questions continued on next page

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11. What shape does this graph have? Does the polonium-211 decay at a constant rate or does the rate decrease over time?

The graph indicates an exponential decay.

The rate of decay decreases over time; i.e., less particles decay over time.

Next, we will examine beta-minus decay. We will again use a simulator called Beta Decay (<https://phet.colorado.edu/en/simulation/legacy/beta-decay>). We will first start with a Single Atom.

12. We will use the hydrogen-3 nucleus for this simulation. How many protons and neutrons does hydrogen-3 have?

1 proton, 2 neutrons

13. After hydrogen-3 decays, what stable nucleus is formed? What are the particles in the nucleus after the decay occurs?

helium-3, which has 2 protons and 1 neutron

14. Does the atomic number change when hydrogen-3 decays to helium-3? What about the mass number?

The atomic number increases by 1; the mass number does not change.

➤ If necessary, click on Reset Nucleus to see the simulation again.

15. Pause the simulation immediately after the decay occurs. What are the particles that are emitted from the nucleus?

One electron and one antineutrino are emitted from the nucleus.

16. This process, called beta-minus decay, occurs when a neutron breaks down into a proton (which stays in the nucleus), and an electron and an antineutrino are emitted from the nucleus. If you knew this before the simulation, could you have predicted the identity of the stable nucleus that is formed?

Yes, if you use a nuclear decay equation where the mass number stays

the same and the atomic number increases by 1

17. What is the half-life of hydrogen-3?

The half-life of hydrogen-3 is roughly 12 years.

18. Repeat the simulation for a total of 10 times. How many times does hydrogen-3 decay before the half-life time out of those 10 times?

Roughly half of the hydrogen-3 nuclei should decay before the half-life.
