Nuclear Processes Name Key 2021

Objective: Distinguish between fission, fusion, and radioactive decay (Obj 4).

Part A: Alpha Decay

Start by opening the PhET model "Alpha Decay". Make sure that you first start by clicking on the single atom tab.

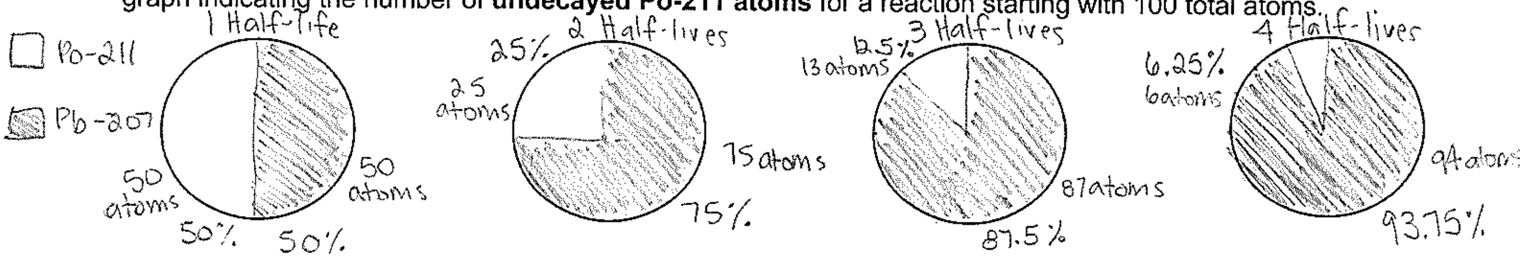
1. Observe the decay of Po-211. Write a nuclear equation for the decay of Polonium-211.

$^{211}_{84}Po \rightarrow ^{207}_{82}Pb + ^{4}_{2}He$ ← same thing $^{4}_{2}\alpha$ (alpha particle = He nucleus)

2. What has to happen within the nucleus in order for an atom of Polonium-211 to decay?

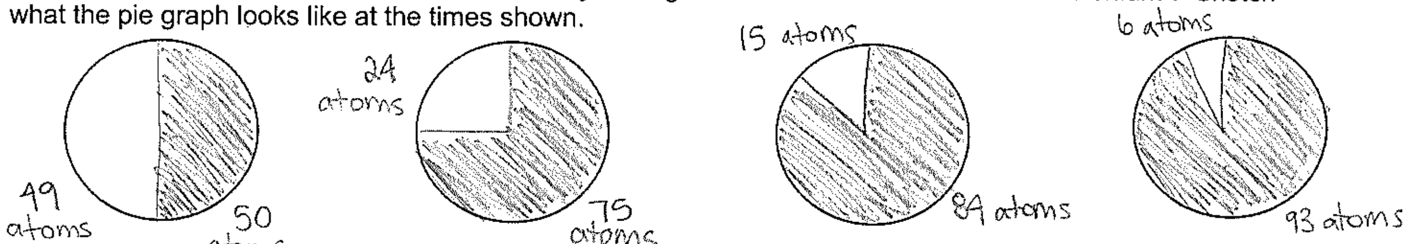
The electric force must overcome the strong force resulting in the release of a Helium nucleus (alpha particle)

The half-life of Po-211 is approximately 500 ms (half a second). **Without using the PhET model**, sketch a pie graph indicating the number of **undecayed Po-211 atoms** for a reaction starting with 100 total atoms.



t= 0.5s t=1.0s t=1.5s t=2s

Now, simulate the decay of 100 Po-211 atoms by adding 100 atoms from the "Bucket o' Polonium". Sketch what the pie graph looks like at the times shown.



t= 0.5s t=1.0s t=1.5s t=2s

3. Compare your prediction to the results that you observed. How can you explain any discrepancies?

Pretty close! Every .5 sec, each atom has a 50% chance of decaying. Just like when you flip a coin, you don't always get heads/tails 50% of the time.

4. Is it reasonable to assume that if you start with 10 atoms of Polonium, that 0.5s later only 5 will remain undecayed? What if you start with 500 atoms? Explain.

It is a reasonable prediction though theoretical does not always match experimental.

Part B: Beta Decay (minus)

Open the "Beta Decay" PhET model. Make sure that you click on the "Single Atom" tab.

5. Observe the beta decay in the PhET model. Write a nuclear equation for the process.

$${}^{3}_{1}H \rightarrow {}^{3}_{2}He + {}^{0}_{-1}e \qquad \left({}^{0}_{-1}\beta\right)$$

Same thing — Beta particle = e^-

6. When an atom undergoes beta decay, where does the beta particle come from? What other particle is produced in this process?

In Beta (-) decay, a neutron turns into a proton & an e^- is released.

Part C: Nuclear Fission

Open the "Nuclear Fission" PhET model. Make sure that you click on the "Fission: One Nucleus" tab.

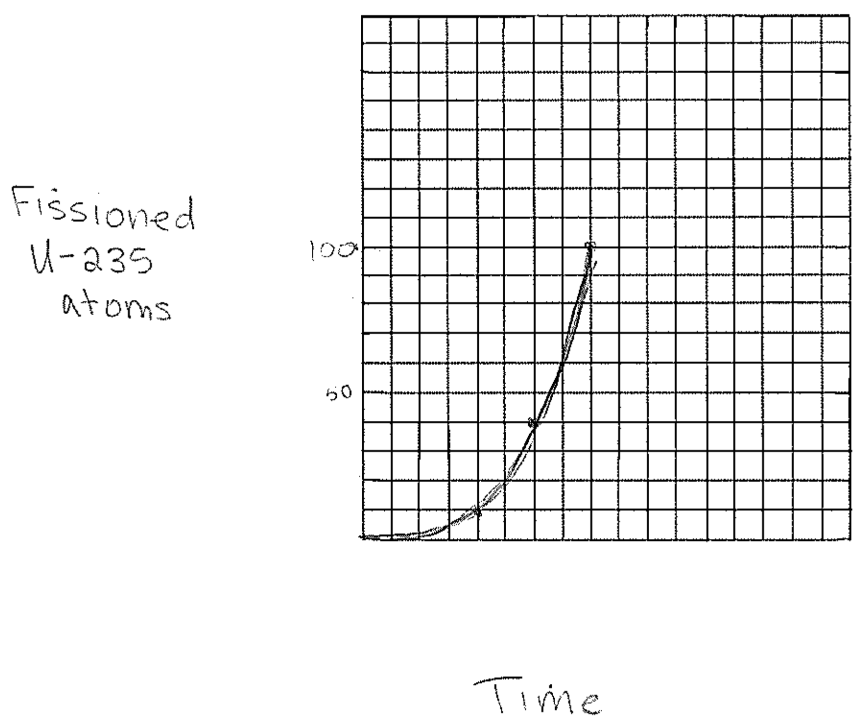
7. Briefly describe the process by which Uranium-235 can be made unstable. Write a nuclear equation for the process.

Uranium-235 becomes unstable when a neutron is fired at it - it becomes Uranium-236.

$${}^{235}_{92}U + n \longrightarrow {}^{236}_{92}U \longrightarrow \bigcirc + \bigcirc + 3n$$

Daughter nucleus — Daughter nucleus

8. Suppose that you have 100 atoms of Uranium-235 and you fire a neutron into a single atom. Sketch a qualitative graph of Fissioned U-235 Atoms vs. Time.



Using the "Chain Reaction" tab within the model, validate your prediction from question ~~7~~ 8.

9. Explain how the PhET model validates/invalidates your prediction made in question ~~7~~ 8 citing specific observations.

The Phet validates my prediction. Each fission reaction releases 3 neutrons that then start a fission reaction in another 3 U-235 nuclei, ultimately ending up with all the U-235 atoms fissioned

10. Using the "Chain Reaction" tab, determine the criteria and settings needed to create an atomic bomb.

In order to create an atomic bomb, you must have enough of the fissionable material and each nucleus must release at least 1 neutron to sustain the chain reaction.

11. Explain why "weapons-grade" Uranium would not likely contain very much Uranium-238.

U-238 can absorb the neutron w/o becoming unstable.

12. Use the "Nuclear Reactor" tab to determine the purpose of control rods within a nuclear fission reactor.

The control rods are able to safely absorb some of the neutrons produced in the fission reactions so it does not produce too much E!

13. Are the following videos(Video A, Video B) good analogies of nuclear fission? If we were to use mousetraps and ping-pong balls to illustrate fission, what would each represent? Is there anything missing from this model?

Ping pong ball → neutron

Mousetrap → U-235 (unstable isotope)

In the mousetrap model, it is possible that not all the traps were set off.