

Name _____

Go to PhET Simulations. Find and open the simulation called Nuclear Fission
http://phet.colorado.edu/simulations/sims.php?sim=Nuclear_Fission

Click on 'Run Now' and select the tab that says 'Fission: One Nucleus'

Fission: One Nucleus:

Experiment with shooting the neutron gun and watch what happens.

- 1) What happens when the U-235 nucleus is "hit" with a neutron? There are a number of things that happen here, describe all of them in as much detail as you can. Use the pause button when needed.
When the nucleus is hit, the atom gains energy. The total amount of energy starts varying instead of staying constant. After a few seconds, the nucleus splits into two daughter nuclei. Three neutrons are also released.

Chain Reaction:

Select the "Chain Reaction" tab at the top. Experiment with changing the settings and shooting the neutron gun and watch what happens. Then answer the questions below.

- 2) Click the 'Reset All' button and then set the initial number of U-235 nuclei to 100 and U-238 to 0. What happens when you fire the neutron gun?
One U-235 nucleus splits apart, releasing three neutrons. Each of these neutrons hits a nucleus causing more nuclei to split. The number of nuclei that split increases until there are no more nuclei left to react.
- 3) Explain what makes this a "chain reaction".
This is a chain reaction because one reaction causes several others to occur. The reaction becomes self-sustaining.
- 4) Click 'Reset' and then set the initial number of U-238 nuclei to 100 and U-235 to 0. Explain what happens when you fire the gun. Does this cause a chain reaction? Try multiple times to start a chain reaction with the U-238. Explain why this happens.
When the gun is fired, the neutron is absorbed into the U-238 nucleus and the atom becomes U-239. No chain reaction takes place because no neutrons are released to continue the reaction.
- 5) What is U-239? In what ways is it different from U-238?
U-239 is an isotope of uranium. It has one more neutron in the nucleus than U-238.
- 6) Set the initial numbers of U-235 nuclei and U-238 nuclei to the numbers in the table below. Repeat each trial multiple times and record the value that occurs most often.

U-235	100	70	50	30	0
U-238	0	30	50	70	100
% of ^{235}U fissioned after 1 firing	99%	97%	40-50%	2-20%	0
# firings required to fission all ^{235}U	2	3	10 - 25	24 or more	N/A

- 7) What happens to the reaction as the proportion of U-238 nuclei increases? Explain why this happens.
The reaction becomes slower. It takes more time to fission all of the U-235. This is because some of the neutrons hit U-238 and are absorbed, changing U-238 to U-239. The more U-238 there is the more likely it is that a neutron will hit a U-238 nucleus.

Nuclear Reactor:

Select the "Nuclear Reactor" tab at the top. Experiment with changing the settings and firing the neutrons and watch what happens. Then answer the questions below.

- 8) Watch very closely to the fission reactions as they happen. Specifically watch what happens to the loose neutrons after the reaction.
- a) What happens if the neutrons hit another nucleus?
If the neutron hits another nucleus, the reaction continues.
- b) What happens if the neutrons hit a control rod?
If the nucleus hits a control rod it is absorbed and no further reaction takes place.
- 9) Compare the chain reaction that occurs when the control rods are inserted further into the reactor versus when they are pulled all/mostly out of the reactor.
When the rods are inserted the chain reaction takes place for a while then stops even though there are unreacted nuclei left. When the rods are withdrawn, the reaction continues until most or all of the nuclei have reacted.
- 10) If the purpose of a nuclear reactor in a power plant is to produce energy, why are there control rods?
The control rods help to control how fast the reaction takes place. You may not always need the same amount of power being produced. They can also keep the reactor from heating up too much.
- 11) The bar graphs on the right of the display show the "Power Output" and the "Energy Produced". What is the difference between these two quantities?
The "Power Output" is showing how much energy is being produced at a given moment in time. The "Energy Produced" shows the total amount of energy released over the course of the simulation.