

Nuclear Fission and Fusion

Why?

Fission and fusion are two processes that alter the nucleus of an atom. Nuclear fission provides the energy in nuclear power plants and fusion is the source of the sun's energy. The use of fission in power plants can help conserve fossil fuels. Without the energy produced by the fusion of hydrogen in the sun, the Earth would quickly change into a cold planet that could not support life as we know it.

Learning Objectives

- Compare and contrast nuclear fission and nuclear fusion.
- Understand the conservation laws that apply to nuclear reactions.

Success Criteria

- Find missing reactants/products in nuclear equations.
- Identify nuclear reactions as examples of fission or fusion.

Vocabulary

- Fission
- Fusion
- Transmutation
- Nuclide

Prerequisites

- Structure of atoms and isotopes.
- Knowledge of mass number and atomic number.
- Atomic symbols including mass number, atomic number, and charge.

Information

Transmutation is the transformation of the nucleus of an atom so that the atom is changed from one element into a different element. This can be accomplished through many types of reactions, including fission and fusion.

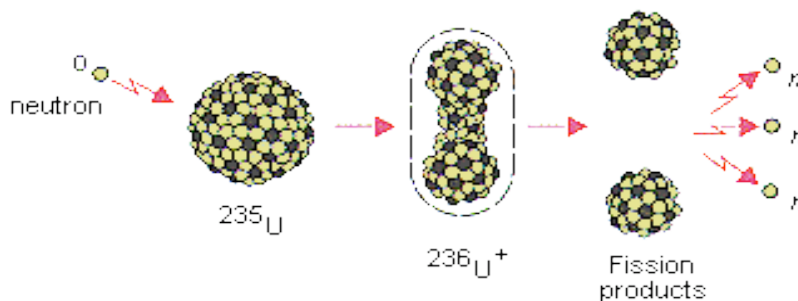
Nuclear transformations always obey two fundamental conservation laws: (1) mass number is conserved and (2) electrical charge is conserved.

Energy and mass are not conserved, but can be inter-converted according to Einstein's equation, $E = mc^2$.

Model

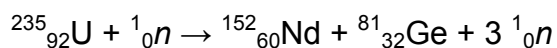
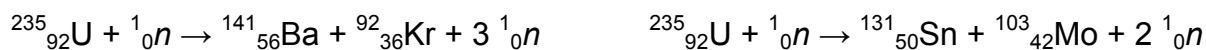
1. Fission

The process of fission occurs when a nucleus splits into smaller pieces. Fission can be induced by a nucleus capturing slow moving neutrons, which results in the nucleus becoming very unstable.



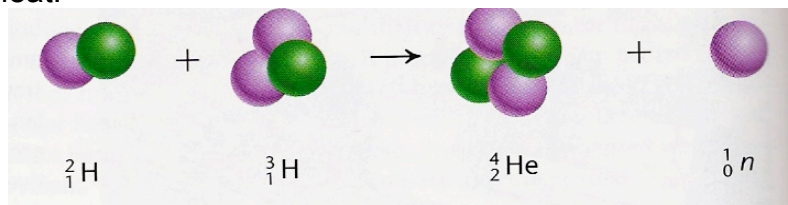
(<http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch23/fission.html>)

The following equations represent fission reactions, where n = neutron.



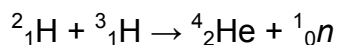
2. Fusion

Fusion occurs when 2 nuclei join together to form a larger nucleus. Fusion is brought about by bringing together two or more small nuclei under conditions of tremendous pressure and heat.



(Phillips, Strozak, Wistrom, Glencoe Chemistry. 2002 p. 766)

The following equations represent fusion reactions, where p = proton.



Key Questions

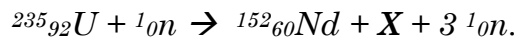
1. What is fission?
2. What is fusion?
3. What is the difference between deuterium, ${}^2_1\text{H}$, and tritium, ${}^3_1\text{H}$?
4. What quantities are conserved in a nuclear transmutation?
5. The fusion equations show the production of atoms of several different elements, even though each reaction begins with isotopes of hydrogen. Knowing the starting elements, can one *predict* what element will form as a result of a given reaction? Explain why or why not.
6. The fission equations show the production of many different elements, even though each reaction begins with uranium-235 and one neutron. How is this possible given the conservation laws for nuclear reactions?

Exercises

1. An equation in the model shows the fusion of two deuterium nuclei to form a nucleus of tritium. Suggest another product that might form in this reaction.



2. Describe *how* to find the identity of the species X in the equation



3. What is missing in the following reaction?



4. An atom of U-235 absorbs a neutron and produces an atom of Sb-125 and four neutrons. Identify the other nuclide formed in this reaction. Write the equation to support your answer.

5. Identify the following equations as fission or fusion.

	Fission or Fusion?
${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_1\text{H} + {}^1_1p$	
${}^{235}_{92}\text{U} + {}^1_0n \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3 {}^1_0n$	
${}^{235}_{92}\text{U} + {}^1_0n \rightarrow {}^{138}_{54}\text{Xe} + {}^{95}_{38}\text{Sr} + 3 {}^1_0n$	
${}^3_2\text{He} + {}^3_2\text{He} \rightarrow {}^4_2\text{He} + 2 {}^1_1\text{H}$	

Research

1. What is the source of energy in fusion and fission reactions? Explain your answer.
2. Name one problem associated with the use of nuclear energy and briefly explain why it is a problem. Also identify how that problem might be addressed.
3. During the 1950's, when many countries performed above ground tests of nuclear weapons, there was much concern about the radioactive fallout when the by-products of uranium fission landed on populated areas. One major concern dealt with the fallout of radioactive strontium isotopes and a suspected link to increases in leukemia and bone cancer. What part of the body might absorb strontium? Explain your answer.