

14.4.3: The Discovery of Fission and the Atomic Bomb

Learning Objectives

- Define and give examples of fission and fusion.
- Classify nuclear reactions as fission or fusion.
- List some medical uses of nuclear energy.

Nuclei that are larger than iron-56 may undergo nuclear reactions in which they break up into two or more smaller nuclei. These reactions are called **fission** reactions. Conversely, nuclei that are smaller than iron-56 become larger nuclei in order to be more stable. These nuclei undergo a nuclear reaction in which smaller nuclei join together to form a larger nucleus. Such nuclear reactions are called **fusion** reactions.

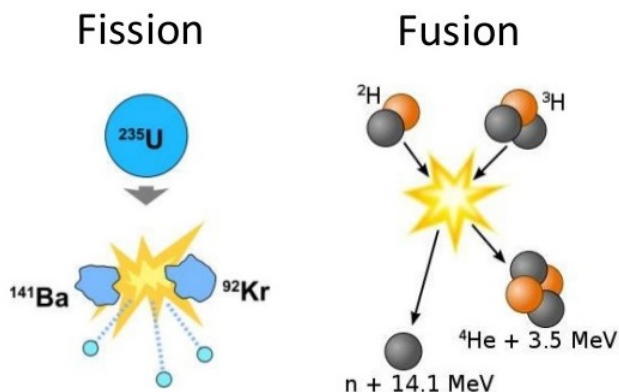
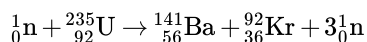


Figure 14.4.3.1: (left) Nuclear fission occurs when one large nucleus is split into two or more smaller nuclei. (right) Nuclear fusion happens when two small nuclei combine to make a larger nucleus.

Fission and Chain Reactions

In both fission and fusion, large amounts of energy are given off in the form of heat, light, and gamma radiation. Nuclear fission was discovered in the late 1930s when U-235 nuclides were bombarded with neutrons and were observed to split into two smaller-mass nuclei.



The products shown are only one of many sets of products from the disintegration of a U-235 nucleus. Over 35 different elements have been observed in the fission products of U-235.

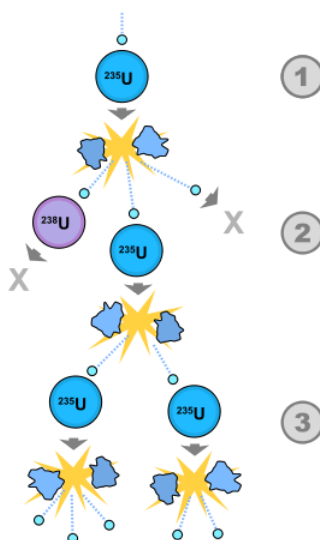


Figure 14.4.3.2: A possible nuclear fission chain reaction. 1. A uranium-235 atom absorbs a neutron, and fissions into two new atoms (fission fragments), releasing three new neutrons and a large amount of binding energy. 2. One of those neutrons is absorbed by an atom of uranium-238, and does not continue the reaction. Another neutron leaves the system without being absorbed. However, one neutron does collide with an atom of uranium-235, which then fissions and releases two neutrons and more binding energy. 3. Both of those neutrons collide with uranium-235 atoms, each of which fissions and releases a few neutrons, which can then continue the reaction. (Public Domain.)

When a neutron strikes a U-235 nucleus and the nucleus captures a neutron, it undergoes fission, producing two lighter nuclei and three free neutrons. The production of the free neutrons makes it possible to have a self-sustaining fission process—a nuclear **chain reaction**. If at least one of the neutrons goes on to cause another U-235 disintegration, the fission will be self-sustaining.

Nuclear Weapons

It is unfortunate that when the topics of radioactivity and nuclear energy come up, most thoughts probably go to weapons of war. The second thought might be about the possibility of nuclear energy contributing to the solution of the energy crisis. Nuclear energy, however, has many applications beyond bombs and the generation of electricity. Radioactivity has huge applications in scientific research, several fields of medicine both in terms of imaging and in terms of treatment, industrial processes, some very useful appliances, and even in agriculture.

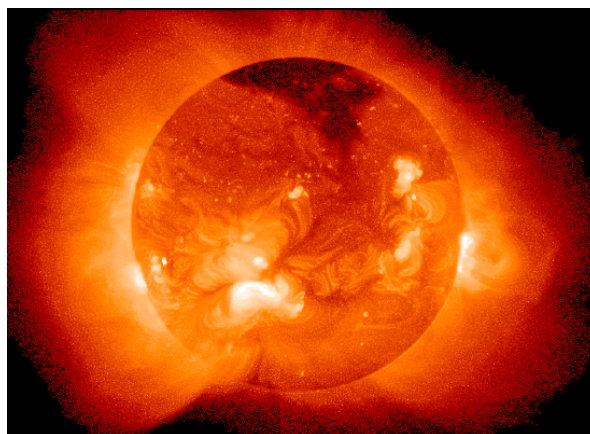


Figure 14.4.3.3: The energy that comes from the sun and other stars is produced by fusion. (Public Domain; NASA.)

Summary and Vocabulary

Naturally radioactive elements exist in the earth and are either alpha or beta emitters. Artificial transmutation of elements can be accomplished by bombarding the nuclei of some elements with alpha or subatomic particles. Nuclear radiation also has many medical uses.

- **Chain reaction** - A multi-stage nuclear reaction that sustains itself in a series of fissions, in which the release of neutrons from the splitting of one atom leads to the splitting of others.
- **Critical mass** - The smallest mass of a fissionable material that will sustain a nuclear chain reaction at a constant level.
- **Fission** - A nuclear reaction in which a heavy nucleus splits into two or more smaller fragments, releasing large amounts of energy.
- **Fusion** - A nuclear reaction in which nuclei combine to form more massive nuclei with the simultaneous release of energy.
- **Control rods** - Rods made of chemical elements capable of absorbing many neutrons, that are used to control the rate of a fission chain reaction in a nuclear reactor.

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