

20.1 Nuclear Equations

nuclear versus chemical

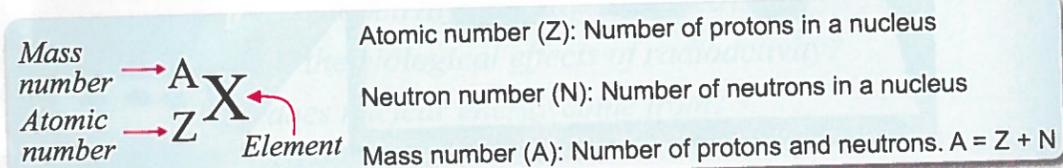
Unlike chemical reactions, which only involve the outer electrons of atoms, nuclear reactions involve and affect the nuclei of atoms. Nuclear reactions can change an element into a different element. This change means that the the number of protons and neutrons are changed during a nuclear reaction. Therefore, in order to represent a nuclear reaction we must explicitly indicate the number of protons and neutrons for each nucleus involved in the reaction.

Chemical reactions create new compounds from elements

Nuclear reactions create new elements from other elements

representing nuclei

The symbols that we use to represent the atomic nucleus contain information about the number of protons and neutrons in the nucleus. The number of protons is represented by the **atomic number (Z)**. The number of neutrons is given by the **neutron number (N)**. The **mass number (A)** is the total number of protons and neutrons in a nucleus.

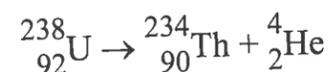


The helium-4 nucleus contains 2 protons and 2 neutrons and it is represented by: ${}^4_2\text{He}$.

The hydrogen nucleus contains one proton and no neutrons and it is represented by: ${}^1_1\text{H}$.

nuclear symbols

The nuclear equation that represents the disintegration of uranium-238, ${}^{238}_{92}\text{U}$, into thorium-234, ${}^{234}_{90}\text{Th}$, and helium-4, ${}^4_2\text{He}$, is written as:



balanced nuclear equation

like a chemical reaction, a nuclear reaction must also be balanced:

- There must be mass number balance. The sum of mass numbers on both sides of the equation must be equal.
- There must also be charge conservation. The sum of atomic numbers on both sides of the equation must be equal.



Chemistry terms

atomic number (Z) - the number of protons in a nucleus.
neutron number (N) - the number of neutrons in a nucleus.
mass number (A) - the number of protons and neutrons in a nucleus.



20.2 Nuclear Reactions: Radioactivity

Nuclear versus chemical

Nuclear reactions can change one element into a different element. They can also change an isotope into a different isotope of the same element. Chemical reactions do not change the types of atoms involved. They only rearrange atoms to form different molecular compounds.

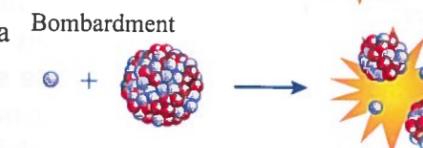
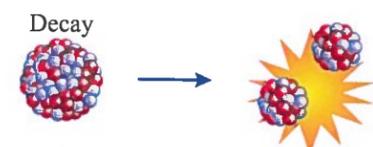
Energy of nuclear reactions

Nuclear reactions involve much more energy than chemical reactions. The energy released by a chemical reaction is related to the rearrangement of the electronic structure of atoms which involves electrical forces. For nuclear reactions the energy released is related to the rearrangement of the atomic nucleus which involves the strong nuclear force, the strongest force in the universe.

Reaction types

There are two main types of nuclear reactions.

- Decay reactions: during which a nucleus breaks up (dissintegrates) spontaneously
- Bombardment reactions: during which a nucleus is struck by another nucleus or some nuclear particle such as a proton or a neutron.



Radioactivity

The four most common types of nuclear decay are: alpha (α) decay, beta (β) decay, gamma (γ) decay, and positron emission (β^+) decay. The elements that decay by α , β , γ , β^+ decay are said to be radioactive. Alpha, beta and positron emission decay release energy that is carried by particles. Gamma decay releases electromagnetic energy. Light, radio waves, microwaves and x-rays are forms of electromagnetic energy. **Radioactivity** is a general term used to describe the property of some elements to break up and release energy associated with matter or waves.



Radiation

The transmission of energy, matter or waves, through space is called **radiation**. Radiation can be dangerous if it has high enough energy to break chemical bonds in molecules. Exposure to radiation over a long period of time can be harmful. Ultraviolet radiation from the sun is an example of radiation that can be harmful to living organisms.

Chemistry terms

nuclear reactions - involve the nuclei and may change one element into another.
radioactivity - property of some element to break up and release energy.
radiation - the transmission of energy through space.