Radioactivity

The nucleus

The number of protons in the nucleus determines atomic number (Z) of the element and the sum of the number of protons and the number of neutrons determines the mass number (A).

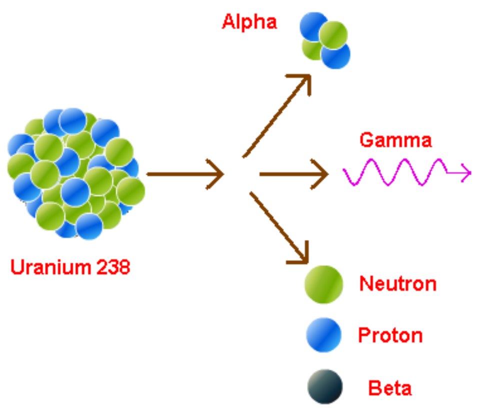
Atoms with the same atomic number but with different mass numbers are called as isotopes of the same element.

Nucleons are collectively protons and neutrons.

It is often used nuclide term for single nuclear species. There are four radioctive series. Three of these are natural radioactive series: The last nuclide of this series is the isotope 209 of bismuth.

What is radioactivity?
What is radioactive decay?
Are there different types of radiation and
how far can radiation penetrate?

Radioactivity is defined as the spontaneous emission of particles or radiation, or both at the same time, from the decay of certain nuclides. In 1896, Antoine-Henri Becquerel discovered radioactivity Radioactivity can be natural or artificial



'Radiation' is energy that travels as waves or particles. Heat, light, sound, microwaves, radar, radio waves, X-rays, alpha and beta particles, and gamma rays are all forms of radiation.

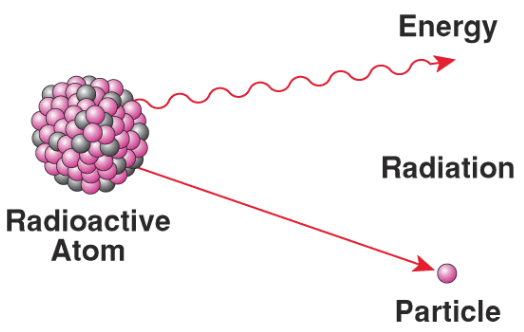
Types of radiation

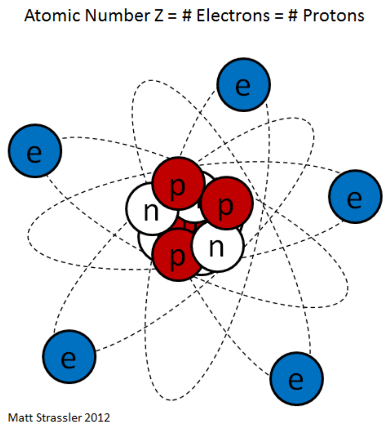
There are two main types of radiation which includes non-ionising and ionising radiation.

1. 'Non-ionising radiation' has less energy than ionising radiation but can still excite molecules and atoms causing them to vibrate faster. Near ultraviolet, visible light, infrared, microwave, radio waves, and low-frequency RF (longwave) are all examples of non-ionising radiation.
2. 'Ionising radiation' has enough energy to change the chemical composition of matter by forcing an atom or molecule to give up an electron. These electrically-charged particles are called ions. Ionising radiation sources include alpha and beta particles, gamma rays, neutrons and cosmic rays.

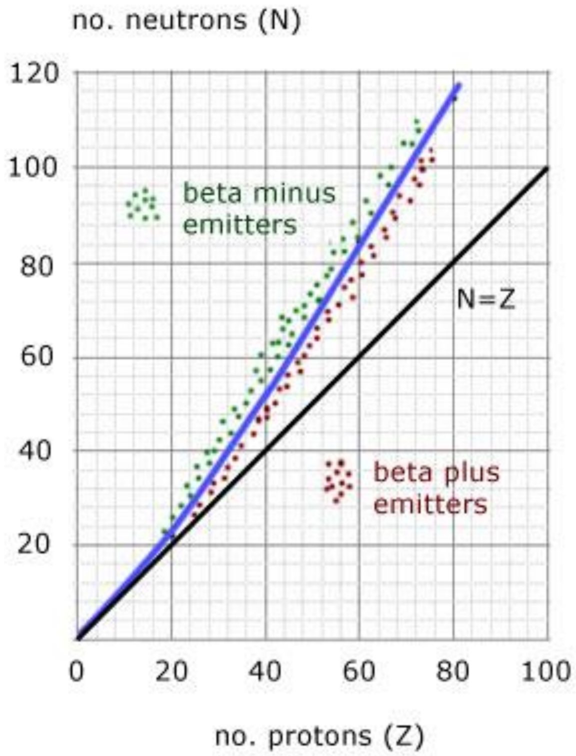
Nuclear Stability

A nucleus that is not be transformed into another configuration without the addition of energy from the outside is stable.





Radioactive decay means that change one nucleus to another. Nuclei with an excess of protons or neutrons in comparison with the stable nuclei will decay toward the stable nuclei by changing protons into neutrons or neutrons into



protons.

Figure shows that a plot of nuclei as a function of proton number, Z, and neutron number, N. Every element with higher Z than Bi is radioactive.

A plot of the number of protons versus the number of neutrons for stable nuclei is referred to as a stability curve. The straight line represents equal number of protons and neutrons and is given for comparision. The curve indicates that the lighter, stable nuclei, in general, have equal numbers of protons and neutrons.

Units of Radioactivity

The number of decays per second, or activity, from a sample of radioactive nuclei is measured in becquerel (Bq), after Henri Becquerel. One decay per second equals one becquerel.

The radiation can be detected using a Geiger counter.

Types of Nuclear Radiation

Alpha decay (particles)

These particles are made up of 2 protons and 2 neutrons: the helium nucleus. Large atoms decay by emitting an energetic alpha particle. These particles are relatively large and positively charged, and therefore do not penetrate through matter very well. For example, uranium-238 will decay to thorium-234. A thin piece of paper can stop alpha particle.

Beta Particles

Beta particles are energetic electrons that are emitted from the nucleus. They are born when a neutron decays to a proton. Beta decay itself comes in two kinds: β+ and β-. This beta particle is an electron with either negative or positive electric charge. Beta particles may travel metres in air and several millimetres into the human body. Beta particles may be stopped by a small thickness of a light material such as aluminium or plastic.

Gamma rays

Gamma rays has much higher frequency and more energetic. This radiation has no charge, and can penetrate most matter easily. They can only be stopped by a dense material such as lead, steel, concrete or several metres of water.

Half-live

The half-life of a radioactive isotope is the time after which, on average, half of the original material will have decayed. Uranium and plutonium have very long half-lives – in the case of uranium-238, around four billion years.

Nuclear fission

An atom's nucleus is split apart released a tremendous amount of energy in the form of both heat and light. Inside a nuclear reactor, uranium atoms are split apart in a controlled chain reaction.

In a chain reaction, neutrons released by the splitting of the atom go off and strike other uranium atoms, splitting those and releasing another lot of neutrons to continue striking more uranium atoms. In nuclear reactors, design features and control rods are used to regulate the splitting so it does not go too fast.

Nuclear fusion

Fusion formes a large nucleus by joining together of smaller nuclei. The sun is powered by nuclear fusion of hydrogen atoms into helium atoms. This gives off heat, light and other radiation.

Notation of Nuclear Reactions

Standard nuclear notation shows the chemical symbol, the mass number and the atomic number of the isotope.

a + b → c + d

$$ {}^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{7}_{3}Li + {}^{4}_{2}He + 2.8\,Mev $$

This equation describes neutron capture in the boron, which is diluted in the coolant.