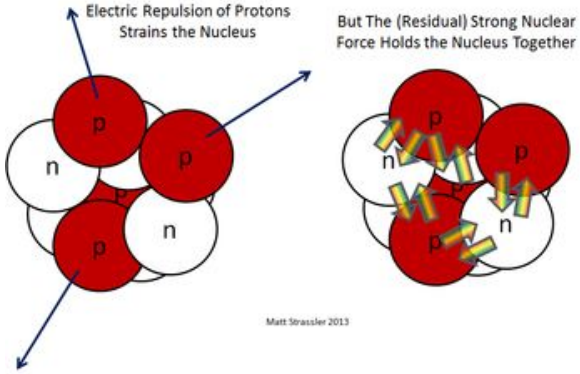
Reading: Stable and Unstable Isotopes **Name: _____**

Elements can be made up of different isotopes. Isotopes are atoms with the same number of protons and electrons, but a different number of neutrons.



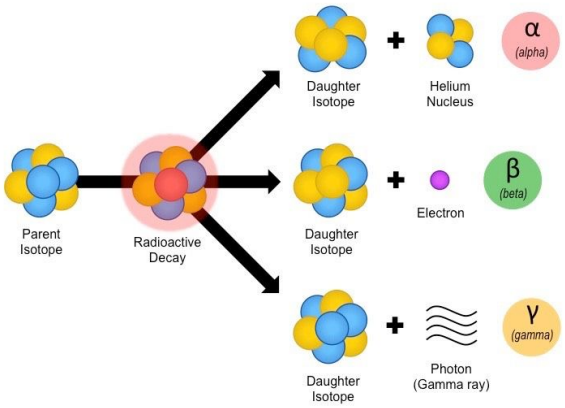
The nucleus of an atom is composed of protons and neutrons. The protons are repelled from each other by a force called the **electromagnetic force**.
The protons and neutrons are held together by the **strong nuclear force** which is the strongest force in the universe.

Sometimes isotopes are stable and happy. These are the elements that we see around us and find in nature. There is around a 1:1 proton to neutron ratio for stable isotopes.

However, some isotopes are unstable. These isotopes are called radioactive isotopes. An isotope is radioactive and unstable if it has too many neutrons or too many protons. With a nucleus that is unstable, the atomic electromagnetic force takes over and radioactive particles are created. All atoms with atomic number 83 and higher only have unstable isotopes and emit radioactive decay.

What is radioactive decay?

When isotopes are unstable they emit energy in the form of radiation. There are three main types of radiation or radioactive decay depending on the isotope: alpha, beta, and gamma radiation.



Different Types of Radioactivity

- **Alpha decay** - Alpha decay is caused when there are too many particles in a nucleus. In this case the element will emit radiation in the form of positively charged particles called alpha particles.
- **Beta decay** - Beta decay is caused when there is an imbalance between protons and neutrons in the nucleus. In this case the element will emit radiation in the form of negatively charged particles called beta particles.
- **Gamma decay** - Gamma decay occurs when there is too much energy in the nucleus. In this case gamma rays (electromagnetic waves) with no overall charge are emitted from the element.

How is it measured?

Radioactivity is measured using a unit called the "curie". It is abbreviated as "Ci". The curie measures how many atoms spontaneously decay each second. The curie was named after Marie and Pierre Curie who discovered the element radium.

What is the half-life of an isotope?

The half-life of an isotope is the time on average that it takes for half of the atoms in a sample to decay.

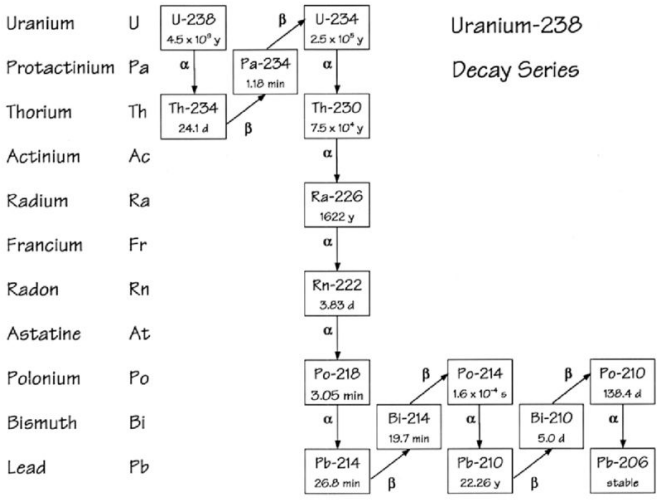
For example, the half-life of carbon-14 is 5730 years. This means that if you have a sample of carbon-14 with 1,000 atoms, 500 of these atoms are expected to decay over the course of 5730 years. Some of the atoms may decay right away, while others will not decay for many thousands more years.

The thing to remember about half-life is that it is a probability. In the example above, 500 atoms are "expected" to decay. This is not a guarantee for one specific sample. It is just what will happen on average over the course of billions and billions of atoms.

Radioactive Decay to other Elements

When isotopes decay they can lose some of their atomic particles (i.e. neutrons, electrons and protons) and turn from one element into another. Sometimes isotopes decay from one unstable isotope into another unstable isotope. This can happen continuously in a long radioactive chain.

An example of a radioactive chain is uranium-238. As it decays, it transforms through a number of elements including thorium, radium, francium, radon, polonium, and bismuth. It finally ends up as a stable isotope as the element lead.



Why is radiation dangerous?

Radiation can alter the structure of cells in our bodies causing mutations which can produce cancer. The more radiation a person is exposed to, the more dangerous it is.

Is some radiation good?

Despite the risks, there are a number of good ways that science has used radiation. These include X-rays, medicine, carbon dating, energy generation, and to kill germs.

Radioactive Isotope	Applications in Medicine
Cobalt-60	Radiation therapy to prevent cancer
Iodine-131	Locate brain tumors, monitor cardiac, liver and thyroid activity
Carbon-14	Study metabolism changes for patients with diabetes, gout and anemia
Carbon-11	Tagged onto glucose to monitor organs during a PET scan
Sodium-24	Study blood circulation
Thallium-201	Determine damage in heart tissue, detection of tumors
Technetium-99m	Locate brain tumors and damaged heart cells, radiotracer in medical diagnostics (imaging of organs and blood flow studies)

Interesting Facts about Radioactivity

- Uranium in the ground can decay into radon gas which can be very dangerous to humans. It is thought to be the second leading cause of lung cancer.
- The half-life of carbon-14 is used in carbon dating to determine the age of fossils.
- Lead is the heaviest element with at least one stable isotope. All elements heavier than lead are radioactive.
- Marie Curie was the first woman to win the Nobel Prize in the development of the theory of *radioactivity* for isolating radioactive isotope and the discovery of two elements, polonium and radium. Marie Curie died in 1934 at age 66 due to her extensive exposure to radioactivity.

Reading Quiz: Circle the correct answer for each question

1) Isotopes of the same element have a different number of what atomic particles?

A. Protons
B. Electrons
C. Neutrons
D. Quarks

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2) What type of isotopes are termed radioactive isotopes?

A. Even
B. Unstable
C. Uneven
D. Stable

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3) What type of radioactive decay will emit particles/waves with no overall charge?

A. Alpha decay
B. Beta decay
C. Gamma decay
D. Delta decay

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4) What type of radioactive decay releases a negatively charged particle/ray?

A. Alpha decay
B. Beta decay
C. Gamma decay
D. Delta decay

5) What type of radioactive decay releases positively charged particles?

A. Alpha decay
B. Beta decay
C. Gamma decay
D. Delta decay

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6) What famous scientist was the original unit of measure for radioactivity named after?

A. Albert Einstein
B. Marie and Pierre Curie
C. Niels Bohr
D. Nicola Tesla

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7) What is the half-life of an isotope?

A. The time it takes for the isotope to fully form
B. The average time it takes for an isotope to begin decaying
C. The average time it takes for half of the atoms to decay
D. The radioactivity of an isotope after 50% of it has decayed

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8) True or False: As isotopes decay they can turn into completely different elements?

A. True
B. False

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9) What disease can be caused by the radiation from isotopes?

A. Influenza
B. Malaria
C. Cancer
D. Bubonic Plague

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10) Which of the following is an example of the use of radiation in modern technology?

A. X-rays
B. Carbon Dating
C. Killing germs
D. All of the above