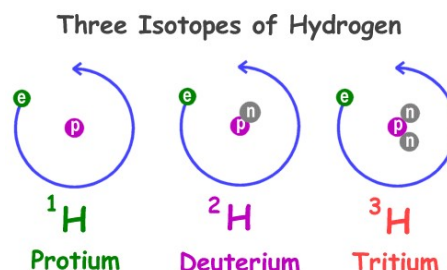


Isotopes & Radioactivity

1. Isotopes

Isotopes are atoms that have the same number of protons and electrons, but a different number of neutrons. Changing the number of neutrons in an atom does not change the element. Atoms of elements with different numbers of neutrons are called "isotopes" of that element.



How many isotopes can an element have?

All elements have a number of isotopes. Hydrogen has the fewest number of isotopes with only three. The elements with the most isotopes are cesium and xenon with 36 known isotopes.

Isotopes stability

Some isotopes are stable and some are unstable. When an isotope is unstable it will decay over time and eventually it will turn into another isotope or element. Unstable isotopes are considered radioactive. Most elements that are found in nature are made up of stable isotopes. The element with the most stable isotopes is tin which has ten different stable isotopes.

Facts about Isotopes

- *Many elements only exist in an unstable or radioactive form.
- *All non-natural or man-made elements are radioactive isotopes.
- *Heavier isotopes tend to react more slowly than lighter isotopes of the same element.
- *Deuterium (the hydrogen isotope with one neutron) can form water with oxygen. This is called "heavy water" as deuterium has twice the mass of normal hydrogen (protium).
- *There are 254 known stable isotopes and 80 elements which have at least one stable isotope.
- *Twenty-six elements only have one stable isotope. These elements are called monoisotopic.

2. Radioactivity

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.

Different Types of Radioactivity

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

How is radioactivity 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.

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. 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.

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.
- *Bismuth is the heaviest element with at least one stable isotope. All elements heavier than bismuth are radioactive.
- *Radioactivity was discovered by the scientist A. H. Becquerel in 1896.