

Radioactivity



Radioactivity is the emission of mass and energy from an atom.

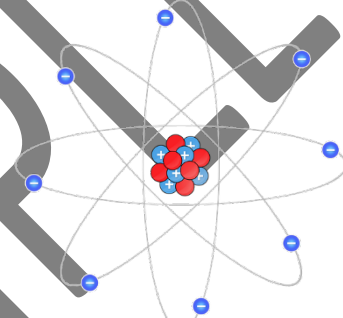
What is Radioactivity?

Radioactivity refers to the emission of mass and energy when an atom's nucleus changes. These changes are the result of instability within the nucleus. In order to understand radioactivity, we need to step back and learn about atoms and isotopes.

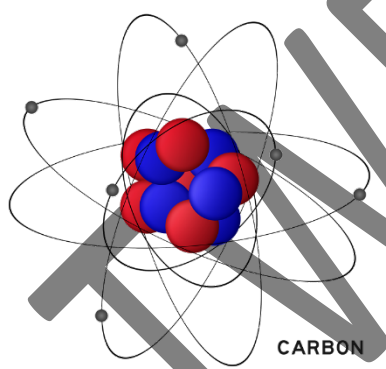
What are Atoms and Isotopes?

An **atom** is the smallest unit of an element (e.g. hydrogen, oxygen). Atoms are composed of a **nucleus** – the center of the atom, which contains **neutrons** and **protons** – and **electrons** that orbit the nucleus. Electrons are negatively charged particles, neutrons carry no charge, and protons are positively charged. Atoms are defined by their **atomic number**, which represents the number of protons in the nucleus. For example, an atom of carbon has 6 protons in its nucleus, and thus an atomic number of 6. The number of electrons determines whether an atom is neutral, positively charged, or negatively charged.

An equal number of electrons and protons denotes a **neutral atom**. An atom with fewer electrons than protons is positively charged. Such an atom is an ion, called a **cation**. Conversely, an **anion** is a negatively charged ion, having more electrons than protons. Neutrons, on the other hand, affect the mass of an atom without affecting its chemical properties.



Atoms consist of protons and neutrons in a nucleus and electrons orbiting that nucleus.



Base carbon, carbon-12, has 6 protons and 6 neutrons, while the isotope carbon-14 has 6 protons and 8 neutrons.

An **isotope** is a version of an element that differs from the base version in the number of neutrons in its nucleus. Thus, it has a different mass than the base version. There are several isotopes of each element. Let's return to our carbon example. The base version of carbon is carbon-12. It has 6 protons and 6 neutrons. Carbon-14, on the other hand, has 6 protons and 8 neutrons. It is still carbon, because it has 6 protons, but its mass is greater than a regular carbon-12 atom. There are two most commonly discussed types of isotopes. The first are **stable isotopes**, which, as their name suggests are in a stable state and don't easily change.

Radioisotopes, on the other hand, are unstable. In order to become stable, they release particles, which in turn releases energy. This process is called **radioactive decay**, and is responsible for radioactivity. Radioisotopes can cycle through many different steps as they become stable. Along the way, they can become different isotopes of the same element, or become a different element altogether. The process of becoming a different element is called **transmutation**. Uranium-238, for example, reaches stability when it becomes lead. Before it reaches this point, however, it becomes a successive string of increasingly stable elements: thorium, radium, radon, polonium, and bismuth.

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Half-lives

Radioactive decay can take anywhere from milliseconds to billions of years, depending on the radioisotope. It is measured in **half-lives**, or the amount of time it takes, on average, for half of the material to decay. This measurement applies no matter how much there is. Thus, in one half-life, half of the original amount of radioisotope will remain, and in a second half-life, half of that (or one quarter the original amount) will be left. Our old friend uranium-238 has a half-life of about four billion years, while iodine-131 has a half-life of only eight days. This means that if you have 4 kg of uranium-238 lying around, in four billion years, half will be gone. Comparatively, half of your iodine-131 will be gone in only 8 days.

Is Radioactivity Dangerous?

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At high doses, radiation can be dangerous for human health. The main effect of radiation is cell death, which can be severe depending on how much radiation is experienced and how long the exposure lasts. Emergency workers are allowed to be exposed to 100 mSv when protecting property and 250 mSv when saving lives. The symptoms of such exposure include nausea and organ damage. If exposed to 3 Sv over the course of one day, these symptoms worsen and are accompanied by the risk of infection due to a reduction in white blood cells. If treated, people under this level of exposure are likely, though not guaranteed, to survive. Above this level, exposure results in additional symptoms, including skin peeling off, hemorrhaging, and sterility.

Above 3.5 Sv, anyone who doesn't receive treatment will die. Above 6 Sv, and even treatment is unlikely to prevent death.

Increasing distance from a radiation source results in decreasing dosage and, consequently, effects. Someone twice as far away from a source as someone else will receive a quarter of the radiation as the closer individual.

High doses of beta particles can build up in tissues and lead to cancer. However, the cancer risk from normal radiation is very low. The risk of cancer from routine medical scans is only 1 in 20,000 per mSv. The absorption of 1 Sv of radiation over a long period of time leads to about a 5% chance of developing cancer.

Radioactivity, like everything else, is dangerous if you receive too much.

Reading Comprehension Questions

1. What is radioactivity?
2. What
3. What are the particles in an atom? What are their charges?
4. How
5. What is a cation? What is an anion?
6. What is
7. What are the two main types of isotopes?
8. What
9. What are the three types of radioactivity? What is released by each?
10. What is a
11. What is radiation measured in? At what level of radiation is treatment ineffective?

Extension Questions

12. Research:
13. Scientists recently found radioactive cesium-137 from the Fukushima-Daiichi power plant that suffered a meltdown in 2011. Where did they find it? What are the implications of this for future potential nuclear meltdowns?
14. Develop

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