Facts about Radioactivity

What is Radioactivity? Which are the Effects on Human Health?

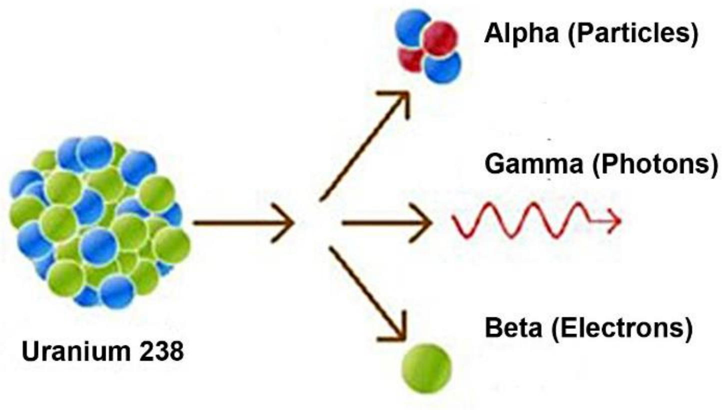
Radioactive decay

Radioactivity refers to the spontaneous emission of radiation from the nucleus of an atom. Atoms are composed of a central nucleus, which contains positively charged protons and uncharged neutrons, surrounded by negatively charged electrons. In stable atoms, the forces within the nucleus keep it intact and prevent any spontaneous emission of particles or energy.

However, in some atoms, the nucleus may be unstable due to an imbalance between the number of protons and neutrons or other factors. This instability leads to a process called radioactive decay, in which the unstable nucleus undergoes a spontaneous transformation to achieve a more stable state. During this process, various types of radiation are emitted from the nucleus.

There are three primary types of radiation emitted during radioactive decay:

1. Alpha particles (α): These are made up of two protons and two neutrons, which are essentially the same as the nucleus of a helium atom. Alpha particles have a positive charge and are relatively large and heavy.
2. Beta particles (β): Beta particles can be either electrons (β-) or positrons (β+). β- particles are essentially high-speed electrons, while β+ particles are positively charged electrons, also known as positrons.
3. Gamma rays (γ): Gamma rays are electromagnetic radiation similar to X-rays but with higher energy. They have no mass or charge and are highly penetrating.



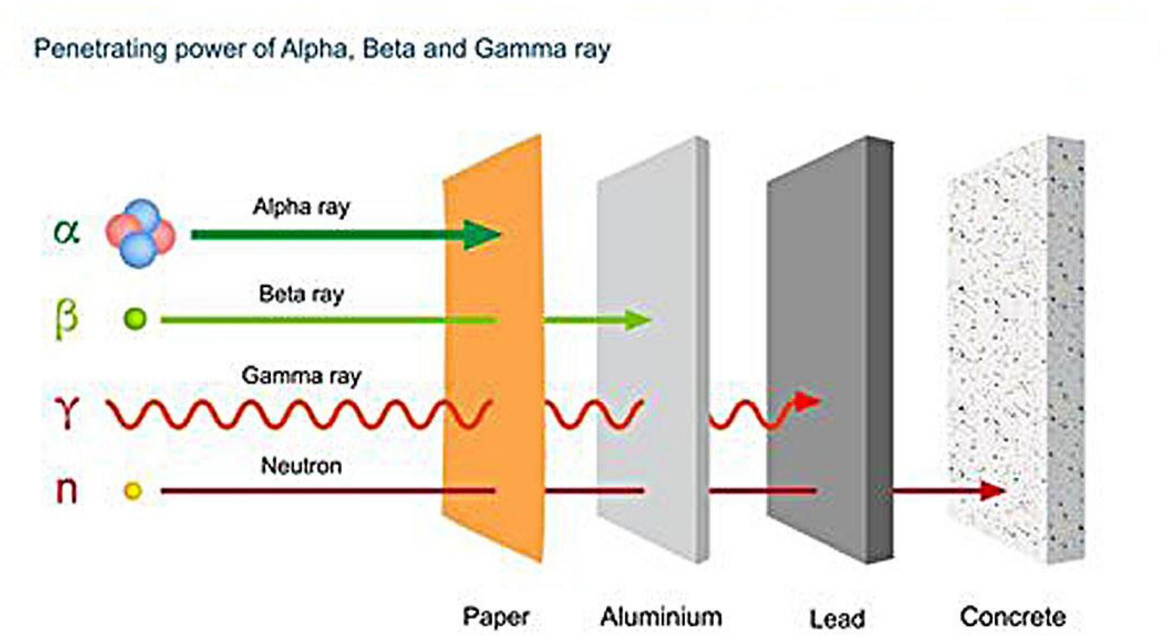
Radioactive decay is a random process, and the rate of decay of a particular radioactive substance is characterized by its half-life, which is the time it takes for half of the radioactive nuclei to decay. The concept of half-life allows us to estimate the rate of decay and the amount of radioactivity present at any given time.

Radioactivity is a natural phenomenon and is also artificially produced in various processes, such as nuclear power generation, medical imaging, and industrial applications. It has both beneficial and harmful effects, depending on its application and level of exposure. Proper handling, containment, and monitoring of radioactive materials are essential to minimize potential risks to human health and the environment.

Efficiency of Shielding

Each type of emission has different penetrating power in the matter and different ionization energy. They can cause damage to life in different ways.

Though the most massive and most energetic of radioactive emissions, the alpha particle is the shortest in range because of its strong interaction with matter. The electromagnetic gamma ray is extremely penetrating, even penetrating considerable thicknesses of concrete. The electron of beta radioactivity strongly interacts with matter and has a short range.



Natural and Man-Made Radiation

We are constantly exposed to naturally occurring radiation and man-made radiation in our environment. The amount of radiation exposure can vary depending on several factors like geographic location, altitude, personal, and occupation.

The primary sources of radiation exposure are:

Natural background radiation

This radiation that is present in the earth's environment and atmosphere from naturally occurring sources like radon gas (rocks, soil, and water) and cosmic ray. Radon is a major cause of lung cancer. It is estimated that radon causes between 3% to 14% of all lung cancers in a country, depending on the national average radon level.

Medical

Diagnostic procedures using radioisotopes are now routine. The most common radioisotope used in diagnosis is technetium-99 (Tc-99). Nuclear medicine uses radiation to provide diagnostic information about the functioning of a person's specific organs.

Radiotherapy can be used to treat some medical conditions, especially cancer, using radiation to weaken or destroy particular targeted cells.

Sterilization of medical equipment is also an important use of radioisotopes.

Demand for radioisotopes in medicine is increasing at up to 5% annually.

Consumer products radiation

This includes radiation from products like smoke detectors some building materials, and certain types of jewelry that contain radioactive materials.

Nuclear industry

This includes radiation exposure from nuclear power plants, nuclear research facilities, and other nuclear-related industries.

In general, the majority of radiation that we are exposed to is natural background radiation. Medical is also a significant source of radiation exposure, especially for people who have frequent medical procedures that ionizing radiation. However, the amount of radiation exposure from any of these sources is usually well below levels that are known to be harmful to human health.

Effects of Radiation on Human Health

The harmful amount of radiation exposure to human health depends on the type of radiation, the energy of the radiation, the duration and the individual's sensitivity to radiation.

In general, ongoing exposure to lower levels of radiation may increase the risk of cancer or other long-term effects. Exposure to high levels of ionizing radiation, such as from radiation therapy or nuclear accidents, can cause acute effects, such as radiation sickness

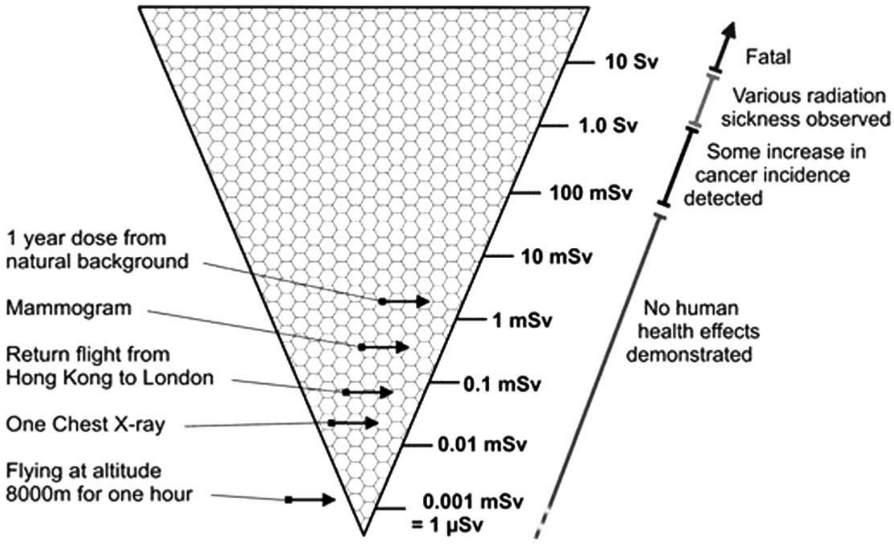
Radiation Dose:

Radiation dose is the amount of radiation absorbed by the organism within a period of time

The radiation dose that a person has received is decisive for the extent of the damage. In radiation medicine, the unit of total absorbed dose is the Gray. One Gray (Gy) is equal to one Sievert (Sv). If the human body was exposed to less than one Gray, disorders of the hematopoietic system may occur. If a person was exposed to three Gray, he or she will have burn-like injuries to the skin and mucous membranes. Above a dose of five Gray, damage to the gastrointestinal tract also occurs. Higher doses cause damage to the brain and spinal cord. If a person has received more than twenty Gray, the chance of survival is minimal.

Small doses of energy do not immediately lead to a cell damage. Larger doses however can lead to DNA damages. If the damage is not repaired completely or not correctly, then the affected cells can degenerate into tumor cells years later. However, many factors play a role in the development of a cancerous tumor, such as diet, lifestyle or even the genetically determined efficiency of the body's own repair systems.

The danger level of radiation exposure can be categorized based on the amount of radiation dose received. The unit of measurement for radiation dose is the Sievert (Sv), or a smaller unit, the millisievert (mSv). Exposure to less than 100 mSv is considered low risk, 100-500 mSv is moderate risk, and exposure to more than 500 mSv is high risk.



Effects of Radiation on Human Health

Radiation Type:

Different types of radiation have different danger levels. For example, alpha particles can be blocked by a sheet of paper and are not very dangerous outside the body, but can cause significant damage if ingested or inhaled. Beta particles are more penetrating and can cause skin burns, while gamma rays are highly penetrating and can cause internal damage even from a distance.

Recommended Maximum Dose Levels

The dangerous dose levels for radiation exposure depend on several factors, including the type of radiation, the duration of exposure, and the sensitivity of the exposed individual. However, here are some general guidelines for the recommended maximum doses for different types of radiation exposure:

Natural background radiation

On average, people are exposed to about **2-3 millisieverts (mSv) of radiation per year** from natural sources, such as cosmic rays and radioactive materials in the earth's crust. This level of exposure is **considered safe**.

Occupational exposure

Workers in industries that handle radioactive materials or perform tasks that involve exposure to radiation may be subject to regulatory limits on their exposure. In the United States, the Occupational Safety and Health Administration (OSHA) sets a **permissible exposure** limit of **50 mSv per year** for radiation workers.

Long-term exposure

Long-term exposure to lower levels of radiation can increase the risk of cancer and other health problems. The risk increases with higher doses and longer exposure times. The **risk of cancer** from radiation exposure is generally estimated to **increase by about 5% per 100 mSv of exposure**.

Acute radiation sickness

Exposure to a high dose of radiation over a short period of time can cause acute radiation sickness, which can be life-threatening. The **threshold for acute radiation sickness** is generally considered to be **around 1,000 mSv**.

Three Rules of Thumb to Protect Yourself from Nuclear Radiation

First >> **Increase distance**

2 m distance, compared to 1 m >> Reduction of dose rate by a factor of 4.
4 m distance, compared to 1 m >> Reduction of dose rate by a factor of 16 (Dose rate is inversely proportional to the square of the distance!).

Second >> **Reduce time of exposure**

Half time of exposure >> Half radiation dose

Third >> **Provide adequate shielding**

Example: Concrete, 20 cm thick >> 85% reduction of gamma dose rate

Radiation Sources

In order to perform nuclear physics experiments, radiation sources are required. Some examples are given below:

Minerals: Some naturally occurring minerals are radioactive due to the presence of certain isotopes of elements such as uranium, thorium, and potassium.

Examples of radioactive minerals include:

Uraninite (also known as pitchblende): This is a uranium ore mineral that is commonly found in granitic rocks and pegmatites.

Carnotite: This is a potassium uranium vanadate mineral that is commonly found in sedimentary rocks.

Monazite: This is a rare earth phosphate mineral that can contain small amounts of thorium and uranium.

Torbernite: This is a copper-uranium phosphate mineral that is commonly found in granitic rocks and pegmatites.

Autunite: This is a calcium uranium phosphate mineral that is commonly found in sedimentary rocks.

It's important to note that while radioactive minerals can be found in nature, they can also pose a health risk if they are not handled properly, especially if they are inhaled or ingested. Therefore, it is important to take appropriate safety measures when handling radioactive minerals.

Examples of Radioactive Isotopes: Co-60 (Gamma), Sr-90 Beta), Cs-137 (Beta, Gamma), available in Scientific Stores such as: 3bscientific.com, imagesco.com, avantorsciences.com, unitednuclear.com

Radium: In the past, radium was used as a radio-luminescent material in luminous watch dials, instrument gauges, and exit signs. The immediate decay product of radium is the dense radioactive gas radon.

Thorium: It is quite possible that some old stock of gas lantern mantles or welding rods still contain tritium, but it is important to use caution and follow proper safety procedures when handling any potentially hazardous material. However, in recent years, safer non-radioactive materials have been developed to replace thorium in most applications.

Antique shops also often have objects and equipment that contain radioactive radiation sources.