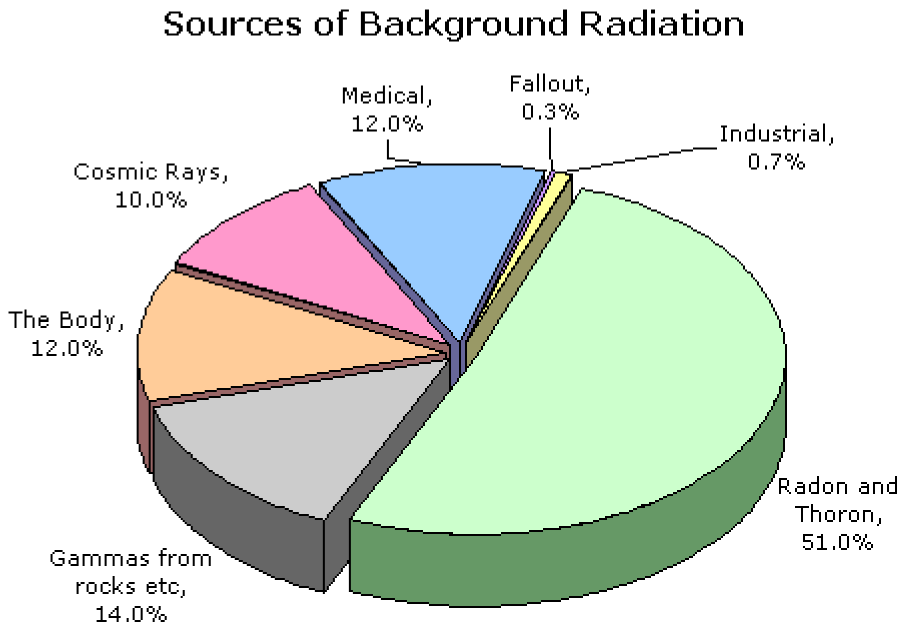
Background radiation:

Background radiation refers to the ionizing radiation that is constantly present in the environment, originating from various natural and artificial sources. Natural sources include cosmic rays from space, radioactive materials in the Earth's crust, and radon gas, while artificial sources include nuclear fallout, medical procedures, and industrial activities. Background radiation is typically low-level and is always present, contributing to the overall radiation exposure that individuals experience on a daily basis.

Sources of background radiation:



Natural sources of background radiation:

Type	Explanation
Cosmic Radiation	High-energy particles from outer space that constantly bombard the Earth's atmosphere, producing ionizing radiation.
Terrestrial Radiation	Radioactive elements such as uranium, thorium, and radium present in the Earth's crust emit radiation that can reach the surface.
Radon gas	Radioactive gas released from the decay of uranium in soil and rocks, which can accumulate in buildings and contribute to background radiation.

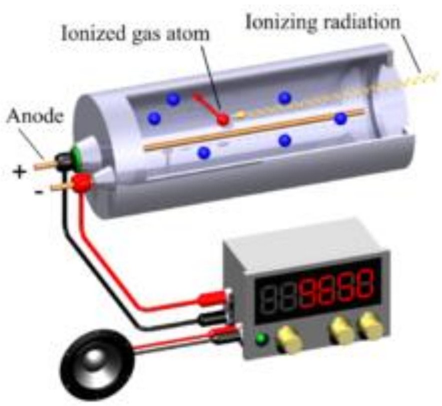
External radiation	Radiation emitted from naturally occurring radioactive materials in the environment, such as rocks, soil, and water.

Non-natural sources of background radiation:

Type	Explanation
Medical procedures	Diagnostic and therapeutic medical imaging procedures, such as X-rays, CT scans, and radiation therapy, contribute to background radiation exposure.
Nuclear power generation	Operations at nuclear power plants and the nuclear fuel cycle can release radioactive materials into the environment, contributing to background radiation.
Industrial activities	Certain industrial processes, such as mining, mineral extraction, and the use of radioactive materials in manufacturing, can result in the release of radioactive substances into the environment.
Nuclear accidents and testing	Incidents such as nuclear accidents, nuclear weapon testing, and the release of radioactive materials from nuclear facilities can lead to increased background radiation levels in affected areas.

How to detect radioactivity:

Radioactivity can be detected using various methods and instruments. One of them being the Geiger-Muller Tube. These handheld devices contain a gas-filled tube that produces an electrical pulse when ionizing radiation interacts with the gas. The pulses are counted and can be used to measure the level of radioactivity in the environment.



Photographic film

To detect radioactivity using photographic film, one can employ the Rutherford-Geiger-Marsden experiment. Begin by obtaining a sheet of unexposed, undeveloped black-and-white photographic film and ensuring it has not been exposed to light or other sources of radiation. Next, place the film in a light-tight container or darkroom and position it near a radiation source, such as a small sample of a radioactive material. After a period of exposure, carefully remove the film and develop it using standard techniques. Upon development, areas of darkening or fogging on the film will be visible, indicating where the radiation interacted with the silver halide crystals in the emulsion.

Count rate:

The count rate in radioactivity refers to the number of radioactive decay events (such as the emission of alpha, beta, or gamma particles) detected per unit of time. To find the count rate, you can use a radiation detector such as a Geiger-Muller counter or a scintillation counter.

Steps:

Step	Task
Prepare the detector	Ensure that the radiation detector is properly set up and calibrated for the type of radiation you are measuring (alpha, beta, gamma, etc.).
Place the detector	Position the radiation detector in the area or near the source where you want to measure the count rate. Ensure that the detector is in an appropriate location to capture the radiation of interest.
Record the counts	Start the detector and record the number of radioactive decay events detected over a specific period of time, such as one minute.
Calculate the count rate	Divide the total number of counts recorded by the duration of the measurement period (e.g., counts per minute) to obtain the count rate.

Corrected count rate:

To calculate the corrected count rate, first measure the background count rate using the radiation detector to account for ambient radiation. Then, measure the total count rate near the radioactive source. Finally, subtract the background count rate from the total count rate to obtain the corrected count rate, which specifically reflects the contribution of the radioactive source while factoring out background radiation. This corrected count rate provides a more accurate measurement of the count rate attributable to the source of interest, aiding in precise radiation detection and measurement.

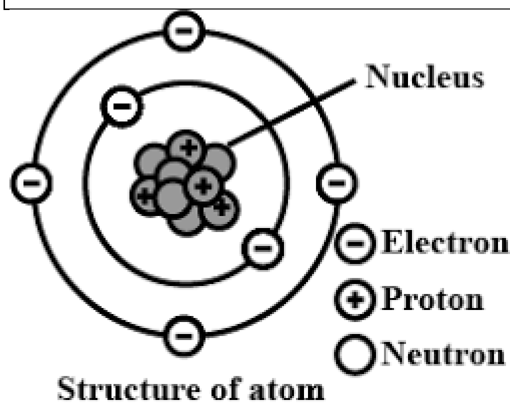
Types of radiation:

Type	Explanation
Alpha decay	In alpha decay, an unstable atomic nucleus emits an alpha particle, which consists of two protons and two neutrons. This process reduces the atomic number of the parent nucleus by two and the mass number by four.
Beta decay	Beta decay involves the emission of a beta particle, which can be either an electron (beta-minus decay) or a positron (beta-plus decay). Beta-minus decay increases the atomic number by one, while beta-plus decay decreases the atomic number by one.
Gamma decay	Gamma decay occurs when an excited nucleus releases gamma radiation, which is a high-energy electromagnetic wave. This process does not alter the atomic or mass number of the nucleus but results in the release of excess energy.

Atomic structure:

Atomic mass number	The atomic mass number, often denoted by the symbol A, represents the total number of protons and neutrons in an atomic nucleus.
Atomic number	The atomic number of an element, denoted by the symbol Z, represents the number of protons found in the nucleus of an atom.
Nucleus	The nucleus of an atom is the central core that contains protons and neutrons, which are collectively known as nucleons. This region is extremely dense and positively charged due to the presence of protons.
Protons	Protons are particles in the nucleus of an atom which are positively charged. They have a relative mass of 1.
Neutrons	Neutrons are also found in the nucleus of an atom like protons. However, neutrons

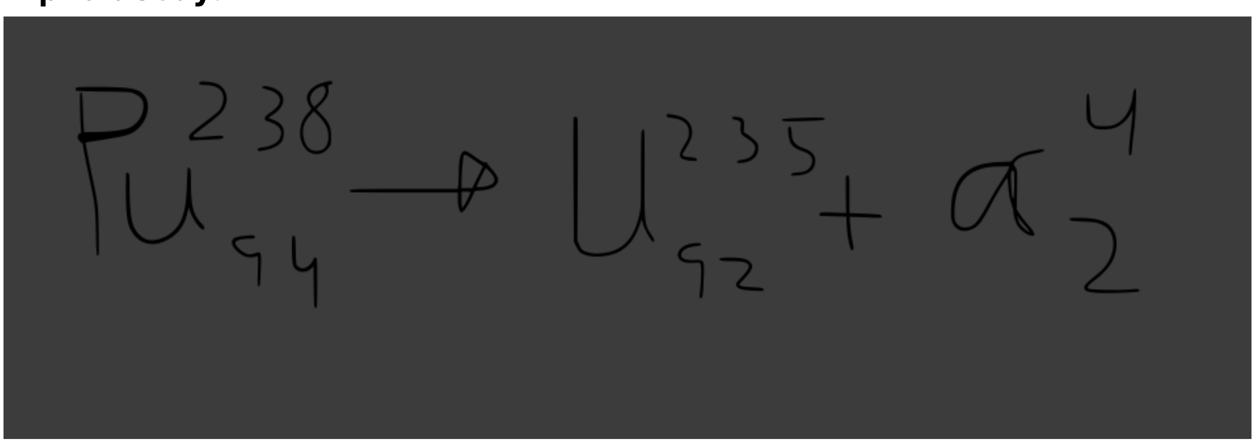
	do not have a charge, but they have a relative mass of 1.
Electrons	Electrons are negatively charged particles which orbit around the nucleus of an atom. Their mass is negligible, so it is considered 0. In a neutral atom the number of electrons always equals the number of protons.



Isotope:

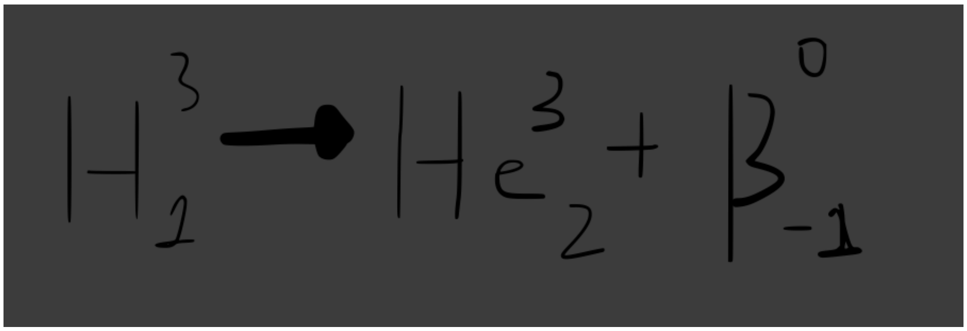
An isotope refers to each of two or more forms of the same chemical element that contain equal numbers of protons but different numbers of neutrons in their atomic nuclei, resulting in variations in atomic mass. Isotopes of an element share similar chemical properties due to identical numbers of protons, but their physical properties, such as mass and stability, may differ due to varying numbers of neutrons. Isotopes are commonly denoted by the element's name followed by a hyphen and the mass number, such as carbon-12 and carbon-14. These variations in isotopes play a significant role in fields such as nuclear science, radiometric dating, and medical imaging.

Alpha decay:



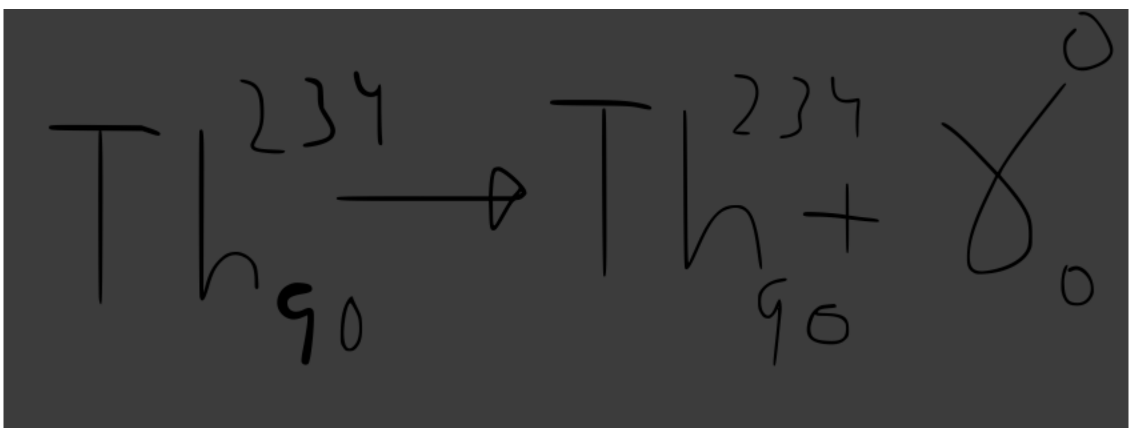
The alpha particle with an atomic mass of 4 and an atomic number of 2 can also be considered a helium nucleus. In alpha decay, a nucleus of 2 protons and 2 neutrons is emitted from the nucleus of an unstable atom, hence creating a new element in the process like plutonium became uranium. In alpha decay, the original element gets 4 subtracted by its mass number and 2 subtracted by its atomic number.

Beta decay:



In beta decay, the symbol ‘β’ can also be replaced by ‘e’ which is the symbol for an electron. Afterall, in beta decay the nucleus emits an electron. In the process of beta decay, a neutron splits into a positron and an electron, the positron stays in the nucleus hence increasing the atomic number by 1 and emits the electron.

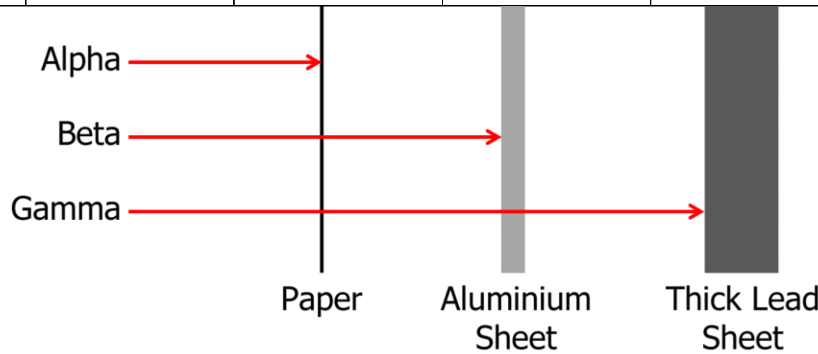
Gamma decay:



Gamma decay is denoted by the symbol “γ”. Gamma decay is the radiation of electromagnetic wave gamma radiation; thus, the radiation has no atomic mass or atomic number. Therefore, the chemical properties of the element will remain unchanged as shown by the equation above.

Particle	Type	Charge	Range of motion	Penetration	Ionization
Alpha	Helium nucleus	2+	Few cm	Stopped by a few mm of paper	High

Beta	Electron	1-	Few cm for 10s	Stopped by a few mm of aluminum	Medium
Gamma	EM wave gamma radiation	0	infinite	Reduced by a few mm of lead	Low



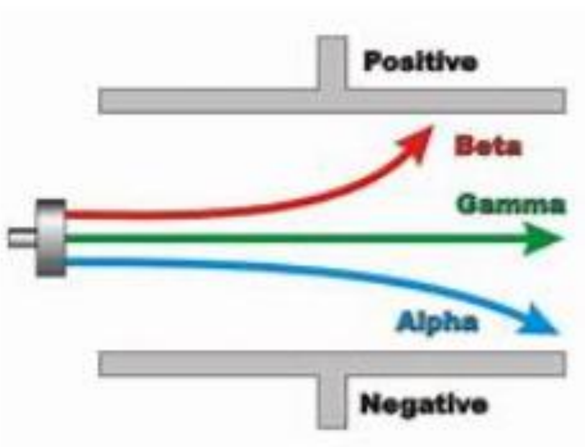
Ionization:

Ionization is the process by which an atom or a molecule gain or loses electrons, resulting in the formation of charged particles called ions. This can occur through various means such as exposure to high-energy radiation, collisions with other particles, or through the application of electric fields. When an atom loses an electron, it becomes positively charged and is called a cation, while when an atom gains an electron, it becomes negatively charged and is called an anion.

Rank of highest ionizing decay	Explanation
1.) Alpha decay	Alpha particles have a high ability to ionize because they are relatively massive and carry a double positive charge. As a result, they interact strongly with other atoms and molecules, causing significant ionization along their path. When alpha particles pass through a medium, they can strip electrons from atoms, creating positively charged ions.
2.) Beta decay	Although they are less massive than alpha particles, beta particles can still cause ionization as they interact with atoms along their path. Beta particles transfer energy to atoms and molecules, leading to the ejection of electrons and the formation of ions. While they may not ionize as strongly as alpha particles due to their lower mass and charge, beta particles still play a significant role in radiation

	interactions and can cause biological damage when they interact with living tissue.
3.) Gamma decay	Gamma decay, which involves the emission of gamma rays, does not directly ionize atoms because gamma rays are electromagnetic radiation and do not carry an electric charge. However, gamma rays have high energy and can indirectly cause ionization by interacting with atoms and transferring their energy to the electrons in the atoms. This process, known as the photoelectric effect or Compton scattering, can lead to the ejection of electrons and the creation of ions.

Deflections in decay:

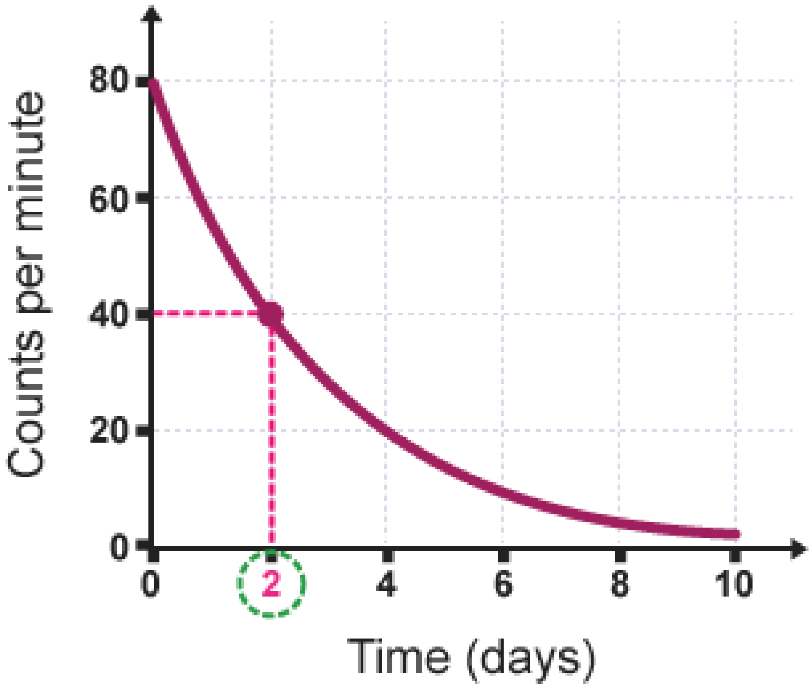


As shown by the diagram, as a positively charged field is present, beta particles (electrons) are attracted to it and hence they are deflected from their previous direction. On the other hand, alpha particles are deflected towards negatively charged fields while gamma radiation does not get deflected as it has no charge.

Half-life:

The half-life of a radioactive substance is the time it takes for half of a sample of the substance to undergo radioactive decay. This means that after one half-life, half of the radioactive atoms in the sample will have decayed into other elements or isotopes, while the other half remains unchanged. The concept of half-life is crucial in understanding the behavior of radioactive materials and is used to determine the rate of decay and the stability of isotopes. Different radioactive isotopes have different half-lives, ranging from fractions of a second to billions of years, and this characteristic is fundamental in fields such as nuclear physics, radiometric dating, and medical imaging.

Half-life diagram:

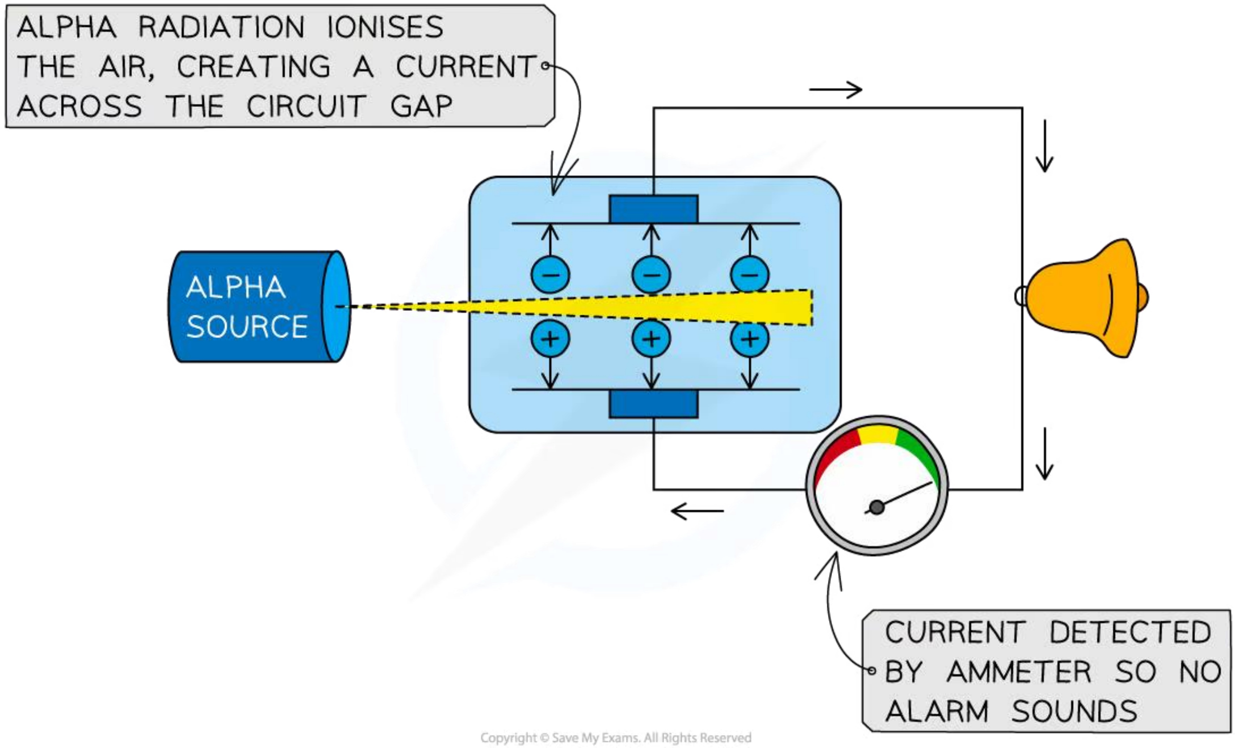


In this diagram, the radioactive substance had an original count rate of 80 counts per minute. To calculate the half-life, you need to find the time value of half the count rate. Hence you divide 80 by 2 to get 40 counts per minute. Then you check the time value at 40 which is 2 days. Finally, your half-life is 2 days.

Uses of radiation:

Radiation has various uses across different fields. In medicine, it is used for diagnostic imaging (X-rays, CT scans) and cancer treatment (radiation therapy). In industry, radiation is used for sterilizing medical equipment, preserving food, and inspecting welds. Additionally, radiation is used in scientific research, energy production (nuclear power), and even in smoke detectors. However, it's important to handle radiation carefully to minimize potential risks.

How a smoke detector works:



A smoke detector works by utilizing a small radioactive source, typically americium-241, to ionize the air inside the detector. The ionization chamber within the detector contains the radioactive source, which emits alpha particles. These alpha particles ionize the air molecules, creating a small electric current within the chamber.

When smoke enters the detector, it disrupts the ionization process, causing the electric current to decrease. This change in current triggers alarm, alerting individuals to the presence of smoke or fire.

Dangers of radioactivity:

The dangers of radioactivity primarily stem from the ionizing radiation emitted by radioactive materials. Exposure to high levels of ionizing radiation can pose significant health risks to humans and the environment.

Danger	Explanation
Increased risk of cancer	Ionizing radiation can damage the DNA in cells, leading to an increased risk of cancer, particularly leukemia, thyroid cancer, and various solid tumors.
Acute radiation sickness	High doses of radiation can cause acute radiation sickness, which may lead to symptoms such as nausea, vomiting,

	diarrhea, and in severe cases, damage to the bone marrow and other vital organs.
Long-term health effects	Chronic exposure to low levels of ionizing radiation may increase the risk of developing non-cancerous diseases such as cardiovascular disease and cataracts.
Environmental impact	Radioactive contamination can persist in the environment for extended periods, affecting ecosystems and potentially causing harm to plants, animals, and humans.
Genetic defects	Exposure to ionizing radiation can cause genetic mutations, potentially leading to hereditary effects in future generations.

Due to these dangers, proper handling, storage, and disposal of radioactive materials are essential to minimize the risks associated with radioactivity. Additionally, stringent safety measures are employed in industries that work with radioactive substances, such as nuclear power generation, medicine, and research, to protect workers and the public from potential harm.

Safe storage of radioactive sources:

Safe storage of radioactive sources is crucial to prevent unauthorized access, accidental exposure, and environmental contamination.

Safety precaution	Explanation
Secure facilities	Radioactive sources should be stored in secure and controlled facilities with limited access to authorized personnel only. These facilities should be designed to prevent unauthorized entry and theft.
Shielding	Radioactive sources should be stored in shielded containers or behind barriers that can effectively attenuate the radiation emitted by the sources.
Labeling and signage	Clearly label all storage areas and containers with the appropriate radiation warning symbols, as well as information about the type and activity of the radioactive material.
Monitoring and alarm systems	Implement radiation monitoring and alarm systems to detect any unauthorized access or abnormal radiation levels in storage areas.

Division and containment	Store radioactive sources in designated areas that are physically separated from other materials and equipped with appropriate containment measures to prevent leakage or spread of contamination.
Inventory control	Maintain a detailed inventory of all radioactive sources, including their location, activity level, and usage history. Regularly verify the inventory to ensure that all sources are properly accounted for.
Regulatory compliance	Comply with all relevant regulations and guidelines for the safe storage of radioactive materials, including periodic inspections and reporting requirements.

By adhering to these principles and incorporating best practices for radiation safety, organizations and facilities can minimize the risks associated with the storage of radioactive sources and protect personnel, the public, and the environment from potential harm.