Mechanism determination by radioisotopes

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Radioactive Isotopes

- Due to nuclear instability, the nucleus exhibits the phenomenon of Radioactivity. It is the phenomenon of the disintegration of heavy elements into comparatively lighter ones by emission in the form of radiation. It was discovered by Henri Becquerel in 1896. Energy is lost due to radiation emitted out of the unstable nucleus of an atom. The driving force of this phenomenon is the force of repulsion also known as electrostatic force, and the forces of attraction of the nucleus which keep the nucleus together. The two forces are considered extremely strong in the natural environment.
- The instability of the atom increases as the size of the nucleus increases because the mass of the nucleus becomes a lot when concentrated. This is the main reason that atoms of Plutonium, Uranium are extremely unstable and undergo the phenomena of radioactivity. Emission and absorption are not noticed easily when it takes place in the atom.

Radioisotopes

- Radioisotopes are radioactive isotopes of an element. They are the atoms containing an unstable combination of neutrons and protons or excess energy in their nucleus. The excess of energy can be used in any of the ways during those processes, the radionuclide is said to undergo radioactive decay.
- Radioactive decay is a property of naturally occurring elements and artificially produced isotopes of the elements. The rate at which a radioactive element decays is expressed in terms of its half-life which is the time required for one-half of any given quantity of the isotope to decay. We have discussed radioactive isotope definition, Radioisotopes, Half-life, Radioactive decay now we will discuss some application of radioactive isotopes.

Laws of Radioactivity

- The rate of decay of the nucleus is independent of the temperature and pressure.
- It follows the law of conservation of charge.
- The emission of energy from radioactivity is accompanied by alpha, beta, and gamma particles.
- The rate of decay of radioactive substances is proportional to the number of atoms that are present at the time.

Uses of Radioactive Isotopes

- Radioisotopes used in medicine have short half-lives, which means they decay quickly and are suitable for diagnostic purposes; others with longer half-lives take more time to decay, which makes them suitable for therapeutic purposes.
- Radioactive isotopes have several other useful applications like they are used in medicine, for example, Cobalt-60 is extensively used as a radiation source to arrest the development of cancer.
- Americium-241 an alpha emitter is used in domestic smoke detectors in the United States.
- Iodine-131 is found effective in treating hyperthyroidism. Another important radioactive isotope is carbon-14, which is used in a breath test to detect the ulcer-causing bacteria Heliobacter pylori.
- They are also used to measure the thickness of metal or plastic sheets, the precision of thickness is indicated by the strength of the radiations that penetrate the material being inspected.

Application of Isotopes

- Isotopes of an element have the same atomic number but different mass numbers.
- Hydrogen is the first element present in the periodic table and has one proton.
- Hydrogen has three isotopes protium, deuterium, and tritium.
- The three isotopes are different because of the difference in the number of neutrons present in them.
- In protium, there is only proton and electron, whereas deuterium contains one neutron and tritium contains two neutrons.
- Out of these three isotopes of hydrogen, tritium is radioactive in nature which emits low energy particles.
- Some radioactive isotopes examples are Tritium, which is used in Boosting Nuclear weapons, Neutron initiator, Self-powered lighting, etc.

- Uranium, which is a weakly radioactive element with an atomic number 92 and symbol U.
- It has two isotopes U-235 and U-238. It is one of the heavy metals that can be utilized as a rich source of concentrated energy.
- Isotope U-235 is mostly used because it can be split readily and yield a large amount of energy when bombarded with a slow-moving neutron. Natural uranium is found as a mixture of two isotopes. U-238 accounts for 99.3% and U-235 around 0.7%.

Types of Radioactivity: Alpha, Beta, and Gamma Decay

- **Alpha Decay:** The nuclear disintegration process that emits alpha particles is termed alpha decay. An example of alpha decay is uranium-238. The alpha decay of U -238 is given as:
- $^{92}U_{238} \rightarrow {}^{4}He_{2} + {}^{234}Th_{90}$
- In the above nuclear change, the uranium atom is transformed into an atom of thorium and gives off an alpha particle. The bottom number in a symbol indicates the number of protons which signifies that the alpha particle has two protons in it that is lost by the uranium atom. The two protons also have a charge of +2. The top number 4 indicates the mass number or the total of the protons and neutrons in the particle.

Beta Decay

- A beta particle is a type of decay in which a high-energy electron is emitted from the nucleus. Nuclei don't contain electrons and yet during decay, an electron is emitted from a nucleus. At the equivalent time that the electron is being ejected from the nucleus, a neutron is becoming a proton. (It is unwise to picture this as a neutron breaking into two pieces are a proton and an electron.) That would be convenient for simplicity, but unfortunately, this is not what actually happens. For convenience, we'll treat decay as a neutron splitting into a proton and an electron. The proton stays within the nucleus, increasing the number of the atom by one. The electron ejects from the nucleus and is the particle of radiation which is called beta.

Gamma Ray

- Gamma-ray is produced in nuclear reactions of all types. In the alpha decay of U -238 nucleus, two gamma rays of different energies are emitted in addition to the alpha particle.
- $^{238}U_{92} \rightarrow {}^{4}He_{2} + {}^{234}Th_{90} + 2{}^{0}\gamma_{0}$