Radioactivity: It is the spontaneous decay or decay of the isotope nucleus with the emission of nuclear particles such as alpha or beta particles, which may be followed by the release of gamma radiation**.** Isotopes in which the decomposition occurs are known as radioisotopes, and it should be noted that the decay process takes place in isotopes, whether in pure form or within chemical compounds, biological and others, and that the decomposition process does not depend at all on natural conditions such as temperature and the state of the isotope**.**

The Nature Of Radioactive Emissions

The emissions of the most common forms of spontaneous radioactive decay are the alpha (α) particle, the beta (β) particle, the gamma (γ) ray, and the neutrino. The alpha particle is actually the nucleus of a helium-4 atom, with two positive charges $^{4}/_{2}He$. Such charged atoms are called ions. The neutral helium atom has two electrons outside its nucleus balancing these two charges. Beta particles may be negatively charged (beta minus, symbol e^-), or positively charged (beta plus, symbol e^+). The beta minus [β^-] particle is actually an electron created in the nucleus during beta decay without any relationship to the orbital electron cloud of the atom. The beta plus particle, also called the positron, is the antiparticle of the electron; when brought together, two such particles will mutually annihilate each other. Gamma rays are electromagnetic radiations such as radio waves, light, and X-rays. Beta radioactivity also produces the neutrino and antineutrino, particles that have no charge and very little mass, symbolized by ν and $\bar{\nu}$, respectively

In the less common forms of radioactivity, fission fragments, neutrons, or protons may be emitted. Fission fragments are themselves complex nuclei with usually between one-third and two-thirds the charge *Z* and mass *A* of the parent nucleus. Neutrons and protons are, of course, the basic building blocks of complex nuclei, having approximately unit mass on the atomic scale and having zero charge or unit positive charge, respectively. The neutron cannot long exist in the free state. It is rapidly captured by nuclei in matter; otherwise, in free space it will undergo beta-minus decay to a proton, an electron, and an antineutrino with a half-life of 12.8 minutes. The proton is the nucleus of ordinary hydrogen and is stable.

Types Of Radioactivity

The early work on natural radioactivity associated with uranium and thorium ores identified two distinct types of radioactivity: alpha and beta decay.

Alpha decay

The nuclei of heavy elements that are heavier than lead have a lower bond energy value per nucleon in the nucleus, so these nuclei are unstable and decompose into lighter and more stable nuclei.

An example is the decay (symbolized by an arrow) of the abundant isotope of uranium, ^{238}U, to a thorium daughter plus an alpha particle:

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He \qquad Q_\alpha = 4.268\ \text{MeV} \qquad t_{1/2} = 4.51 \times 10^9\ \text{years}$$

Given for this and subsequent reactions are the energy released (Q) in millions of electron volts (MeV) and the half-life ($t_{1/2}$). It should be noted that in alpha decays the charges, or number of protons, shown in subscript are in balance on both sides of the arrow, as are the atomic masses, shown in superscript.

Beta decay

Some nuclei of radioisotopes emit other particles known as beta particles, and these particles are electrons or positrons. A positron is a particle whose mass is equal to the mass of an electron but has a positive charge.

Beta minus decay

an energetic negative electron is emitted, producing a daughter nucleus of one higher atomic number and the same mass number. An example is the decay of the uranium daughter product thorium-234 into protactinium-234:

$$^{234}_{90}\mathrm{Th} \longrightarrow {}^{234}_{91}\mathrm{Pa} + e^{-} + \bar{\nu} \qquad Q_{\beta+} = .263\ \mathrm{MeV} \qquad t_{1/2} = 24.1\ \mathrm{days}$$

In the above reaction for beta decay, v represents the antineutrino. Here, the number of protons is increased by one in the reaction, but the total charge remains the same, because an electron, with negative charge, is also created.

Beta-plus decay

During the 1930s new types of radioactivity were found among the artificial products of nuclear reactions: beta-plus decay,
or positron emission, and electron capture. In beta-plus decay an energetic positron is created and emitted, along with a neutrino, and the nucleus transforms to a daughter, lower by one in atomic number and the same in mass number. For instance, carbon-11 (*Z* = 6) decays to boron-11 (*Z* = 5), plus one positron and one neutrino:

$$^{11}_{6}C \longrightarrow {}^{11}_{5}B + e^{+} + \nu \qquad Q_{\beta^+} = 0.97\ \text{MeV} \qquad t_{1/2} = 20.4\ \text{min}$$

Types of Beta decay

There are three types of beta decay

1-The electron decay

$${}^{1}_{0}n \rightarrow {}^{1}_{1}p + \beta^{-} + v^{-}$$

2-The positron decay

$${}^{1}_{1}p \rightarrow {}^{1}_{0}n + \beta^{+} + v$$

3-The electron cupture

$${}^{0}_{-1}e + {}^{1}_{1}p \rightarrow {}^{1}_{0}n + v$$

Antineutrino: It is a particle that if it meets a particle when moving at a relatively specific speed, then they perish together as a material mass and produce this annihilation in the form of electromagnetic radiation.

Gamma decay

A third type of radiation, gamma radiation, usually accompanies alpha or beta decay. Gamma rays are photons and are without rest mass or charge. Alpha or beta decay may simply proceed directly to the ground (lowest energy) state of the daughter nucleus without gamma emission, but the decay may also proceed wholly or partly to higher energy states (excited states) of the daughter. In the latter case, gamma emission may occur as the excited states transform to lower energy states of the same nucleus. (Alternatively to gamma emission, an excited nucleus may transform to a lower energy state by ejecting an electron from the cloud surrounding the nucleus. This orbital electron ejection is known as internal conversion and gives rise to an energetic electron and often an X-ray as the atomic cloud fills in the empty orbital of the ejected electron. The ratio of internal conversion to the alternative gamma emission is called the internal-conversion coefficient.)

$$^{11}_{6}C \longrightarrow\ ^{11}_{5}B + e^{+} + \nu \qquad Q_{\beta^+} = 0.97\ \text{MeV} \qquad t_{1/2} = 20.4\ \text{min}$$

Proton Radioactivity

Proton radioactivity, discovered in 1970, is exhibited by an excited isomeric state of cobalt-53, ^{53m}Co, 1.5 percent of which emits protons:

$$ {}^{53m}_{27}Co \xrightarrow{1.5\%} {}^{52}_{26}Fe + p \qquad Q_p = 1.57 \text{ MeV} $$

$$ {}^{53m}_{27}Co \xrightarrow{98.5\%} {}^{53}_{26}Fe + e^+ + \nu \qquad t_{1/2} = 0.243 \text{ sec} $$

Electron capture

Electron capture (EC) is a process in which decay follows the capture by the nucleus of an orbital electron. It is similar to positron decay in that the nucleus transforms to a daughter of one lower atomic number. It differs in that an orbital electron from the cloud is captured by the nucleus with subsequent emission of an atomic X-ray as the orbital vacancy is filled by an electron from the cloud about the nucleus. An example is the nucleus of beryllium-7 capturing one of its inner electrons to give lithium-7:

$$ {}^{7}_{4}Be + e^- \longrightarrow {}^{7}_{3}Li + \nu \qquad Q_{EC} = 0.8616 \text{ MeV} \qquad t_{1/2} = 53 \text{ days} $$