Marwari college Darbhanga

Subject---physics (Sub)

Class--- B.Sc. part 2

Group----C

Topic—Natural Radioactivity (Nuclear physics)

Lacture series – 03.

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Radioactivity

Radioactivity is the spontaneous emission of radiation in the form of particles or high energy **photons** resulting from a nuclear reaction. It is also known as radioactive decay, nuclear decay, nuclear disintegration, or radioactive disintegration. While there are many forms of **electromagnetic radiation**, they are not always produced by radioactivity. For example, a light bulb may emit radiation in the forms of heat and light, yet it is not radioactive. A substance that contains unstable **atomic nuclei** is considered to be radioactive.

NATURAL RADIOACTIVITY:-

Nuclear reactions which occur spontaneously are said to be an example of natural radioactivity. There are three naturally occurring radioactive series among the elements in the periodic table. These are known as the uranium series, the actinium series and the thorium series, each named after the element at which the series start (except the actinium series which starts with a different uranium isotope). Each series decays through a number of unstable nuclei by means of alpha and beta emmission, until each series end on a different stable isotope of lead

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.

Alpha decay

In alpha decay, an energetic helium ion (alpha particle) is ejected, leaving a daughter nucleus of atomic number two less than the parent and of atomic mass number four less than the parent. 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:

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

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-minus decay

In 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, ν 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.

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.)