DECAY OF RADIOACTIVE MATERIAL (URANIUM) AND ITS APPLICATION

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Abstract

The estimation of radiation dose to man from both exterior or interior publicity to radionuclides requires understanding of the energies and intensities of the atomic and nuclear radiations emitted throughout the radioactive decay process. The availability of evaluated decay records for the massive number of radionuclides of activity is therefore of imperative importance for radiation dosimetry. This lookup paper consists of a compilation of decay facts for Alpha, Beta and Gamma radiations. The radionuclides chosen for this research paper include these occurring naturally in the environment, those of workable importance in pursuits or unintentional releases from the nuclear fuel cycle, those of fusion reactor technology.

KEYWORDS-Alpha, Beta, Gamma, Half-Life, Radioactive Decay, Uranium

Introduction

This lookup paper includes a compilation of decay records for Alpha(α), Beta(β), Gamma(γ) radiations. The radionuclides chosen for this research paper consist of these happening naturally in the environment, those of plausible importance in routine or unintentional releases from the nuclear gas cycle. The bodily strategies worried in radioactive decay which produce the distinctive sorts of radiation located are discussed in Research paper. This lookup paper consists of regulation and derivation of radioactive decay, derivation of decay regulation, half-life and mean lifestyles of radioactive particles. This research paper also contain calculation for half-life, mean lifestyles and a solved example of uranium (i.e. which is a radioactive element) which undergoes decay. In alpha decay an atom with atomic quantity 'Z' and mass number 'A' emits an alpha particle (a 4He nucleus with Z = 2 and A = 4) producing a daughter atom with atomic wide variety 2-2 and mass number A-4.

Beta decay consists of the procedures of 0-, 0+, and electron seize decay. As with alpha decay, the immediate radiations resulting from the de-excitation of excited states in the daughter nucleus produced with the aid of beta decay are blanketed in the decay scheme of the father or mother radionuclide.

Gamma Radiation When a gamma ray (y) is emitted by a nucleus in a transition from greater to a lower power state, the gamma-ray power is equal to the strength difference between the two levels minus the strength of nuclear throwback. At the place E(y) is the gamma-ray power in kilo electron volts (keV) and A is the mass variety of the nucleus. The electricity of nuclear shrink back is commonly negligible besides for high-energy transitions in light nuclei.

Equation Methodology

- **Law of Radioactive Decay**

When a radioactive material undergoes α, β or γ-decay, the number of nuclei undergoing the decay, per unit time, is proportional to the complete quantity of nuclei in the sample material. So,

If N = total number of nuclei in the pattern and

ΔN = wide variety of nuclei that endure decay in time Δt then,

$$\frac{\Delta N}{\Delta t} \propto N$$

$\frac{\Delta N}{\Delta t} = \lambda N$.... (1)

where λ = radioactive decay steady or disintegration constant. Now, the alternate in the variety of nuclei in the sample is, dN = – ΔN in time Δt. Hence, the rate of exchange of N (in the restriction Δt→ 0) is,

$$\frac{dN}{dt} = -\lambda N$$

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Now, integrating both aspects of the above equation, we get,

$NN_0 \int \frac{dN}{N} = \lambda tt_0 \int dt$ ……… (2)

Or, $\ln N - \ln N_0 = -\lambda(t - t_0)$…… (3)

Where, N_0 is the range of radioactive nuclei in the pattern at some arbitrary time t_0 and N is the quantity of radioactive nuclei at any subsequent time t. Next, we set t_0 = 0 and rearrange the above equation (3) to get,

$$\ln\left(\frac{N}{N_0}\right) = -\lambda t$$

$\mathrm{N(t) = N_0 e - \lambda t}$…….. (4)

Equation (4) is the Law of Radioactive Decay.

- **The Decay Rate**

In radioactivity calculations, we are greater fascinated in the decay rate $R \ \left(= -\frac{dN}{dt}\right)$ than in N itself. This charge gives us the number of nuclei decaying per unit time. Even if we don't be aware of the quantity of nuclei in the sample, with the aid of certainly measuring the wide variety of emissions of α, β or γ particles in 10 or 20 seconds, we can calculate the decay rate. Let's say that we consider a time interval dt and get a decay depend ΔN (= –dN). The Decay price is now described as,

$$R = -\frac{dN}{dt}$$

Differentiating equation (4) on each sides, we get,

$$R = \lambda N_0 e - \lambda t$$

Or, $R = R_0 e - \lambda t$……… (5)

Where, R_0 is the radioactive decay rate at time t = 0, and R is the fee at any subsequent time t. Equation (5) is the alternative structure of the Law of Radioactive Decay. Now we can rewrite equation (1) as follows,

R = λN … (6)

where R and the variety of radioactive nuclei that have now not but passed through decay have to be evaluated at the identical instant.

- **Half-Life and Mean Life**

The total decay fee of a pattern is also recognized as the activity of the sample. The SI unit for size of activity is 'Becquerel' and is defined as,

1 Becquerel = 1Bq = 1 decay per second

An older unit, the curie, is nevertheless in common use:

1 curie = 1 Ci = 3.7 × 1010 Bq (decays per second)

There are two ways to measure the time for which a radionuclide can last.

- Half-life T1/2 – the time at which both R and N are decreased to half of their initial values
- Mean life τ – the time at which each R and N have been decreased to, e-1 of their initial values.

- **Calculating Half-Life**

Let's discover the relation between $\frac{T_1}{2}$ and the disintegration consistent λ. For this, let's input the following values in equation (5),

$\mathrm{R} = (\frac{1}{2})\mathrm{R}_0$ and $\mathrm{t} = \frac{\mathrm{T}_1}{2}$

So, we get $\frac{T_1}{2} = \frac{(\ln 2)}{\lambda}$

Or, $\frac{T_1}{2} = \frac{0.693}{\lambda}$…… (7)

- **Calculating Mean life**

Next, let's locate the relation between the suggest life τ and the disintegration regular λ. For this, let's reflect onconsideration on equation (5),

- The wide variety of nuclei which decay in the time interval: 't' to 't + Δt' is: R(t)Δt = $(\lambda N_0 e - \lambda \Delta t)$.
- Each of them has lived for time 't'.
- Hence, the whole existence of all these nuclei is tλN0e–λt Δt

Hence, to achieve the imply life, we combine this expression over all the instances from zero to ∞ and divide through the complete number of nuclei at t = 0 (which is N0).

$$\tau = \frac{(\lambda \mathrm{N}_0 \ \int_0^\infty \mathrm{te}{-}\lambda\mathrm{tdt})}{\mathrm{N}_0}$$

$$= \lambda \int_0^\infty \mathrm{te} - \lambda\mathrm{tdt}$$

On solving this integral, we get

$$\tau = \frac{1}{\lambda}$$

Therefore, we can summarise the observations as follows:

$$\frac{T_1}{2} = \frac{(\ln 2)}{\lambda} = \tau \ln 2 \ldots\ldots (8)$$

Literature Review

Concrete has been used in the building of nuclear amenities because of two primary properties, its structural energy and its potential to defend radiation. Concrete structures have been recognized to ultimate for hundreds of years, but they are additionally regarded to deteriorate in very short durations of time. The use of concrete in nuclear amenities for containment and shielding of radiation and radioactive substances has made its performance crucial for the safe operation of the facility. The available literature was searched for reviews on the effects of radiation and temperature on concrete deterioration. The outcomes of low doses, 1010 neutron/cm2, are mentioned to reason deterioration. For high radiation exposure, >1020 neutron/cm2 or >1010 rads of gamma, concrete has been pronounced to showcase reduction in compressive and tensile power and a marked make bigger in volume. The effects of long-term exposure of concrete to increased temperatures are a loss of water in the concrete main to a decrease in compressive strength, adjustments in the modulus of elasticity, creep resistance, conductivity, and diffusivity. Generally speaking, the threshold of degradation is 95qC, and the effects increase with growing temperature and time exposure.

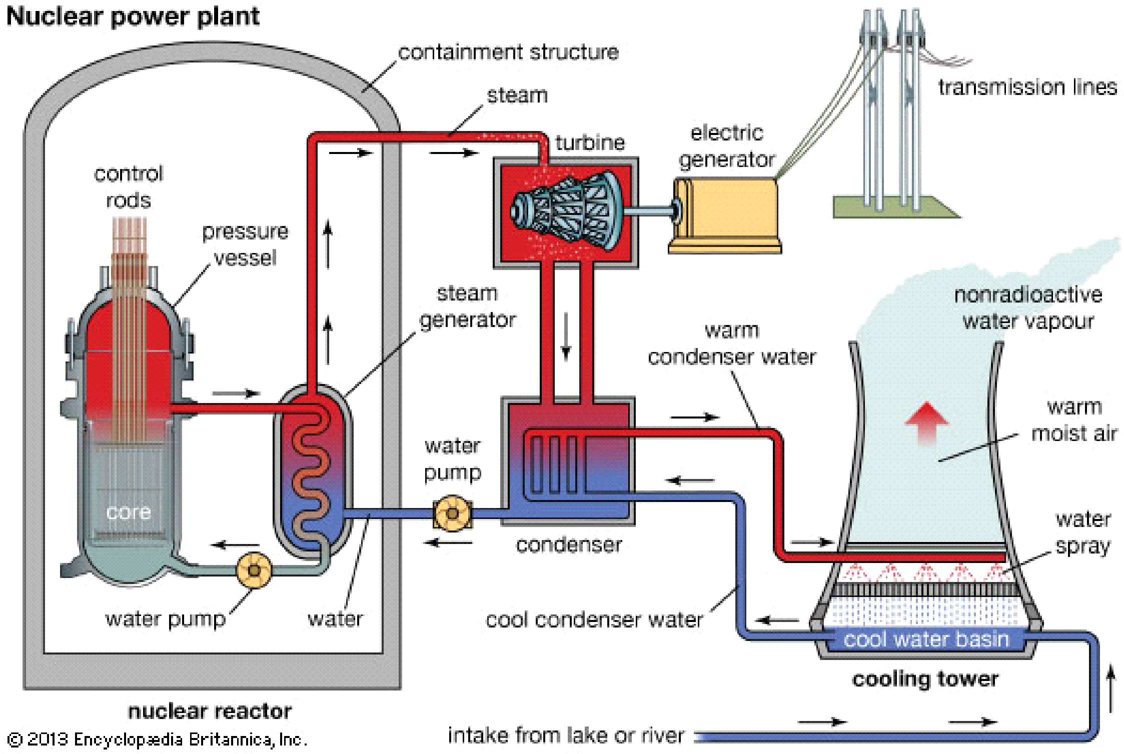

Fig.: Nuclear Power Plant

Components of a Reactor

Chain reactions of fissionable substances can be managed and sustained barring an explosion in a nuclear reactor. Any nuclear reactor that produces power with the aid of the fission of uranium or plutonium with the aid of bombardment with neutrons ought to have at least five components: nuclear gasoline consisting of fissionable material, a nuclear moderator, reactor coolant, manipulate rods, and a shield and containment system.

The reactor works via isolating the fissionable nuclear material such that a essential mass can't be formed, controlling each the flux and absorption of neutrons to enable shutting down the fission reactions. In a nuclear reactor used for the production of electricity, the strength launched with the aid of fission reactions is trapped as thermal electricity and used to boil water and produce steam. The steam is used to turn a turbine, which powers a generator for the production of electricity. A Light-Water Nuclear Fission Reactor for the Production of Electric Power. The fuel rods are made of a corrosion-resistant alloy that encases the partly enriched uranium fuel; managed fission of 235U in the fuel produces heat. Water surrounds the gas rods and moderates the kinetic power of the neutrons, slowing them to extend the likelihood that they will set off fission. Control rods that include elements such as boron, cadmium, or hafnium, which are very positive at absorbing neutrons, are used to manipulate the charge of the fission reaction. A warmness exchanger is used to boil water in a secondary cooling system, creating steam to power the turbine and produce electricity. The extensive hyperbolic cooling tower, which is the most seen portion of the facility, condenses the steam in the secondary cooling circuit; it is regularly located at some distance from the genuine reactor.

Explanation

The strength source of a nuclear power plant is fission reaction. In fission reaction we begin with an unstable atom (uranium-235) which splits apart into two small more stable atoms. When we go from something that is actually very unstable (uranium-235) to aspect that is more stable (barium and krypton), electricity is released. Now to break up the uranium atom we need to worsen it, what we do is we strike a neutron into this large uranium atom, which converts it into uranium-236 from uranium -235. Uranium-236 is extraordinary unstable atom and splits up into krypton-92 and barium-141, which are way greater stable. Other than launch of energy, 3 free neutrons are additionally launched in the process. These neutrons similarly strike some other 3 uranium atoms and begins up a chain reaction, supporting in getting a great amount of thermal energy.

Observation

1. Advantages

- There is no pollution in generating electricity from nuclear reaction in nuclear power plant.
- The working fee of reactor is pretty low, and the existence of a reactor is about 50-60 years before it goes out of business
- Reliability and consistency over a long duration of time is the top aspect which makes it a gorgeous source of power, as it does not depend upon weather conditions.
- Uranium is reachable in a massive quantity and going to final longer than fossil fuels.
- If any country units up a nuclear strength plant, then it does not have to worry about the fluctuating fees of fossil fuels and worlds environmental policies and regulations.

2. Applications

Uranium is normally used as gasoline in nuclear strength reactors for electrical energy generation. Beyond presenting about 14% of the world's electricity, there are many main other uses of uranium thru the production of radio-isotopes, including:

- Medicine: radio-isotopes are used for diagnosis and research. Radio-diagnosis can be used to detect sickness by injecting sure radio-elements into the human physique and staring at their paths.

Radio-therapy uses ionizing radiation to kill most cancers cells and nuclear remedy depends on radio-active tablets that target particular organs;

- Food-processing industry: radio-isotopes are used to sterilize clean merchandise because irradiation kills parasites, pests and bacteria;
- Industrial sector: radio-isotopes are used for industrial X-ray requirements. This technique is widely used in metallurgy, automobiles, aeronautics for inspection of protection and quality;
- Space industry: when space probes are required to function in places a way away from the sun, the solely on hand solution for the production of heat and electricity is the use of radio-isotopes;
- History and culture: carbon-14 in samples of archaeological stays is used to estimate their age.

Conclusion

This lab was once to obtain a better perception of radioactive decay. I gained a higher understanding of what a half-life is in relation to radioactive decay by using the usage of pennies to show how at every half-life the share left of the parent isotope is 50% less than it was before. Then we seemed greater carefully as an isotope showing its daughter isotope, which is what the father or mother isotope turns into after it totally decays. While searching at this isotope, it confirmed that relying on the isotope the half-life can take a longer period or a shorter period of time.

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