Saitechinfo NEET-JEE Academy

Here's an outline for lecture notes on **Radioactivity**:

Radioactivity: An Overview

Definition of Radioactivity
Radioactivity is the spontaneous emission of particles or electromagnetic radiation from the unstable nucleus of an atom. This process leads to the transformation of an element into a different isotope or another element.

History of Radioactivity

- Discovered by Henri Becquerel in 1896 while studying phosphorescent materials.
- Pioneered by Marie Curie and Pierre Curie, who isolated radioactive elements like polonium and radium.

Types of Radioactive Decay

1. **Alpha Decay (α-decay)**
   - Involves the emission of an alpha particle (two protons and two neutrons).
   - Results in a decrease of atomic number by 2 and mass number by 4.
   - Example: Uranium-238 decays into Thorium-234.

2. **Beta Decay (β-decay)**
   - **Beta-minus (β^-) decay**: A neutron is converted into a proton and an electron (beta particle) is emitted.
   - **Beta-plus (β^+) decay**: A proton is converted into a neutron, and a positron is emitted.
   - Alters the atomic number by ±1 without changing the mass number.
   - Example: Carbon-14 decays into Nitrogen-14 (β^- decay).

3. **Gamma Decay (γ-decay)**
   - Emission of gamma rays, which are high-energy photons.
   - Occurs after alpha or beta decay, as the nucleus shifts from a higher energy state to a lower energy state.
   - Does not change the atomic or mass numbers of the nucleus.

Characteristics of Radioactive Decay

- **Random Nature**: Radioactive decay is a random process and is not affected by external conditions such as temperature or pressure.

- **Decay Series**: Some heavy elements undergo a series of decays until a stable isotope is formed, such as the uranium, thorium, and actinium decay series.
- **Decay Law**: The rate of decay is proportional to the number of undecayed nuclei and follows an exponential law.

Key Concepts in Radioactivity

1. **Half-Life (t½)**
   - The time required for half the nuclei in a radioactive sample to decay.
   - Specific to each radioactive isotope and remains constant over time.
   - Formula: $N = N_0 \, e^{-\lambda t}$, where N is the remaining quantity, N_0 is the initial quantity, λ is the decay constant, and t is time.

2. **Activity (A)**
   - The rate of decay of a radioactive substance, measured in becquerels (Bq) or curies (Ci).
   - $A = \lambda N$, where λ is the decay constant and N is the number of undecayed nuclei.

3. **Mass-Energy Equivalence**
   - Explained by Einstein's equation, $E = mc^2$.
   - In radioactive decay, a small amount of mass is converted into energy, which is released as radiation.

Applications of Radioactivity

1. **Medical Applications**
   - **Radiotherapy**: Uses radioactive isotopes to treat cancer by destroying cancerous cells.
   - **Diagnostic Imaging**: Isotopes like Technetium-99m are used in imaging organs.

2. **Energy Generation**
   - **Nuclear Reactors**: Utilizes the fission of uranium or plutonium isotopes to generate electricity.

3. **Carbon Dating**
   - Carbon-14 dating is used to determine the age of archaeological and geological samples by measuring the remaining C-14 content.

4. **Industrial Applications**
   - Used in measuring thickness of materials, sterilizing medical equipment, and in smoke detectors.

Safety and Environmental Impact

- **Radiation Hazards**: Exposure to high doses of radiation can cause biological damage, including radiation sickness and increased cancer risk.
- **Radiation Protection**: Involves minimizing exposure time, increasing distance from the radiation source, and using shielding materials like lead or concrete.

- **Nuclear Waste Disposal**: Proper disposal and storage of nuclear waste are crucial to avoid environmental contamination.

Conclusion

Radioactivity plays a critical role in various fields, from energy production to medical treatments. Understanding the nature and types of radioactive decay allows for safe and effective use of radioactive materials while mitigating associated risks.
