

6. NUCLEAR PHYSICS

Learning Objectives

After learning this unit, students will be able to

- ❖ Define radio activity.
- ❖ Distinguish between natural and artificial radio activity.
- ❖ Relate the properties of alpha, beta and gamma rays.
- ❖ State Soddy and Fajan's displacement law of nuclear disintegration.
- ❖ Understand the concept of nuclear fission and nuclear fusion.
- ❖ Identify fissionable materials.
- ❖ Analyze controlled and uncontrolled chain reactions.
- ❖ Explain the principle of atom bomb and hydrogen bomb.
- ❖ List the uses of radio activity.
- ❖ Understand the components of a nuclear reactor.
- ❖ Identify the precautionary measures while handling a radioactive material.

Important Notes and Results

- There have been 29 radioactive substances discovered so far. Most of them are rare earth metals and transition metals
- Uranium, named after the planet Uranus, was discovered by Martin Klaproth, a German chemist in a mineral called pitchblende.
- Electron Volt (eV) is the unit used in nuclear physics to measure the energy of small particles. It is nothing but the energy of one electron when it is accelerated using an electric potential of one volt.
- $1\text{eV} = 1.602 \times 10^{-19}$ joule
- 1 million electron volt = 1 MeV = 10^6 eV (mega electron volt)
- The energy released in a nuclear fission process is about 200 MeV.

- Nuclear fusion is the combination of two lighter nuclei. The charge of both nuclei is positive. According to electrostatic theory, when they come closer they tend to repel each other. This repulsive force will be overcome by the kinetic energy of the nuclei at higher temperature of the order of 10^7 to 10^9 K.
- The nuclear bomb that was dropped in Hiroshima during World War II was called as 'Little boy'. It was a gun-type bomb which used a uranium core. The bomb, which was subsequently dropped over Nagasaki, was called as 'Fat man'. It was an explosion type bomb, which used a plutonium core.
- Sun fuses about 620 million metric tons of hydrogen each second and radiates about 3.8×10^{26} joule of energy per second. When this energy is radiated towards the Earth, it decreases in its intensity. When it reaches the Earth its value is about 1.4 kilo joule per unit area in unit time.
- Our mother age is nearly 4.54×10^9 years (around 45 Crore 40 lakh years).
- Dosimeter is a device used to detect the levels of exposure to an ionizing radiation. It is frequently used in the environments where exposure to radiation may occur such as nuclear power plants and medical imaging facilities. Pocket dosimeter is used to provide the wearer with an immediate reading of his/her exposure to X-rays and γ rays.
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S.No.	NUCLEAR FISSION	NUCLEAR FUSION
1	The process of breaking up (splitting) of a heavy nucleus into two smaller nuclei is called 'nuclear fission'.	Nuclear fusion is the combination of two lighter nuclei to form a heavier nucleus.
2	Can be performed at room temperature.	Extremely high temperature and pressure is needed.
3	Alpha, beta and gamma radiations are emitted.	Alpha rays, positrons, and neutrinos are emitted.
4	Fission leads to emission of gamma radiation. This triggers the mutation in the human gene and causes genetic transform diseases.	Only light and heat energy is emitted.

S.No.	Natural radioactivity	Artificial radioactivity
1	Emission of radiation due to self-disintegration of a nucleus.	Emission of radiation due to disintegration of a nucleus through induced process.
2	Alpha, beta and gamma radiations are emitted.	Mostly elementary particles such as neutron, positron, etc. are emitted.
3	It is a spontaneous process.	It is an induced process.
4	Exhibited by elements with atomic number more than 83.	Exhibited by elements with atomic number less than 83.
5	This cannot be controlled.	This can be controlled.