SNS COLLEGE OF ALLIED HEALTH SCIENCES- COIMBATORE 35

DEPARTMENT : RADIOGRAPHY AND IMAGNG TECHNOLOGY

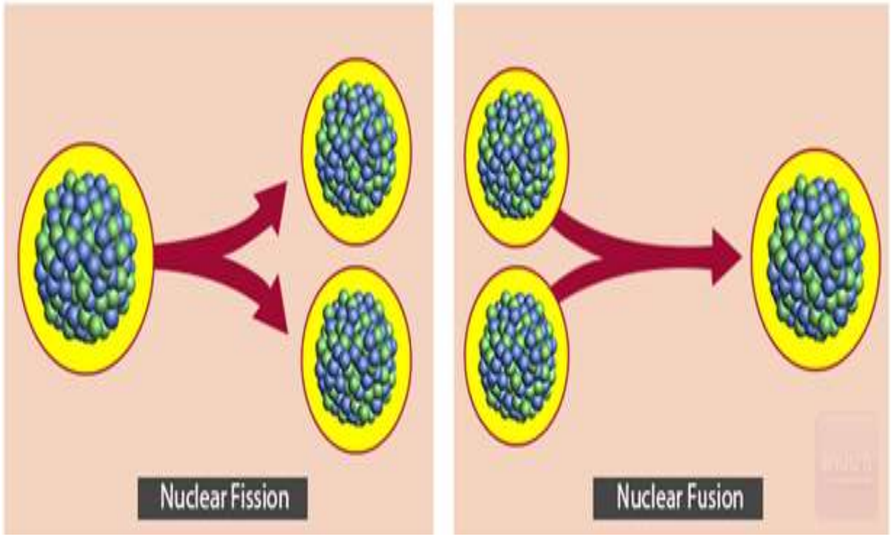
SUBJECT : GENERAL PHYSICS, RADIATION PHYSICS AND PHYSICS OF DIAGNOSTIC RADIOLOGY

PAPER : PAPER II (UNIT 3 – RADIOACTIVITY)

TOPIC : 1. NUCLEAR FISSION
2. NUCLEAR FUSION
3. NUCLEAR REACTOR

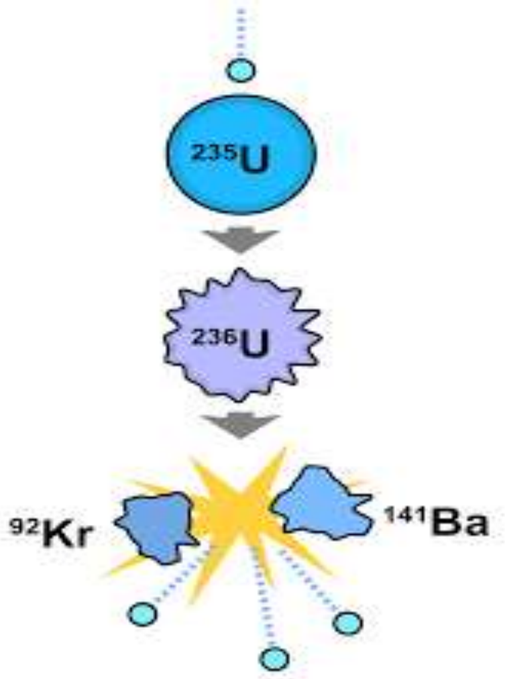
NUCLEAR FISSION AND FUSION

- Nuclear fission and fusion are nuclear process by which the atoms are changed. Fission is the division of one large atom into two, and fusion is the combination of two lighter atoms into a larger one.



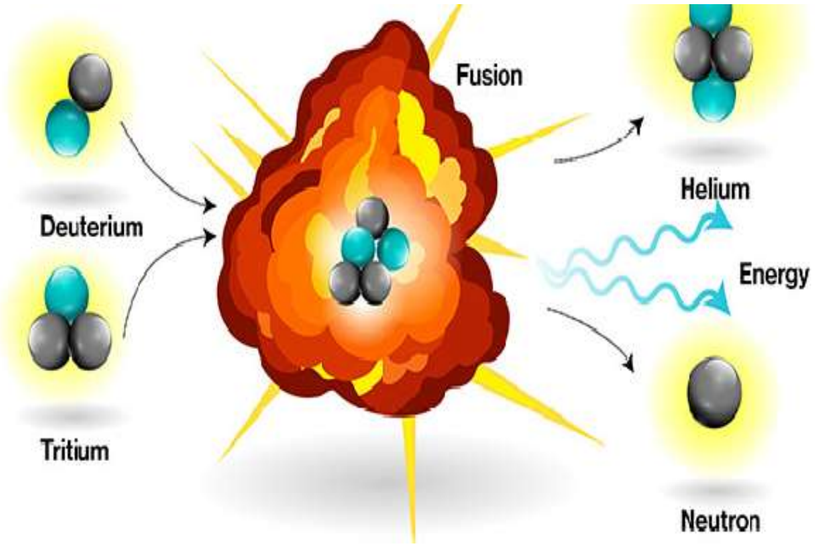
NUCLEAR FISSION

- The larger atom splits into two or more smaller atoms.
- In fission, the nucleus of the large atom, is bombarded with neutrons. In this process the parent nucleus splits into two daughter nuclei and two or three neutrons also go out.
- When the atom is splits a large amount of energy is released then they will split continued again and again. This is called as a chain reaction. The chain reactions produces a large amount of energy when this energy is released in a controlled manner it can be used to generate electricity. and when this energy is released in uncontrolled manner it causes nuclear explosion.
- **Example :** $_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}U^{236*} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\ {}_{0}n^{1}$ **+ Energy (200MeV)**



NUCLEAR FUSION

- Nuclear fusion is occurs when one atom is combined with another atom.
- Nuclear fusion is the process of making a single heavy nucleus from two lighter nuclei.
- Nuclear fusion is the process that mainly converts hydrogen into helium.
- **Example :** nuclear fusion occurs naturally in the sun and other stars inside the sun and stars, four hydrogen atoms fusses together into helium atom. In this process produces a tremendous amount of energy is generated
- **Uses :** Nuclear fusion is used in nuclear power reactor to produce electricity and as a hydrogen bomb (weapon).
- **Deuterium-Tritium Equation : $1H^2 + 1H^3 \rightarrow 2\ He^4 + 0n^1$ + Energy (17.59 MeV)**



NUCLEAR REACTOR

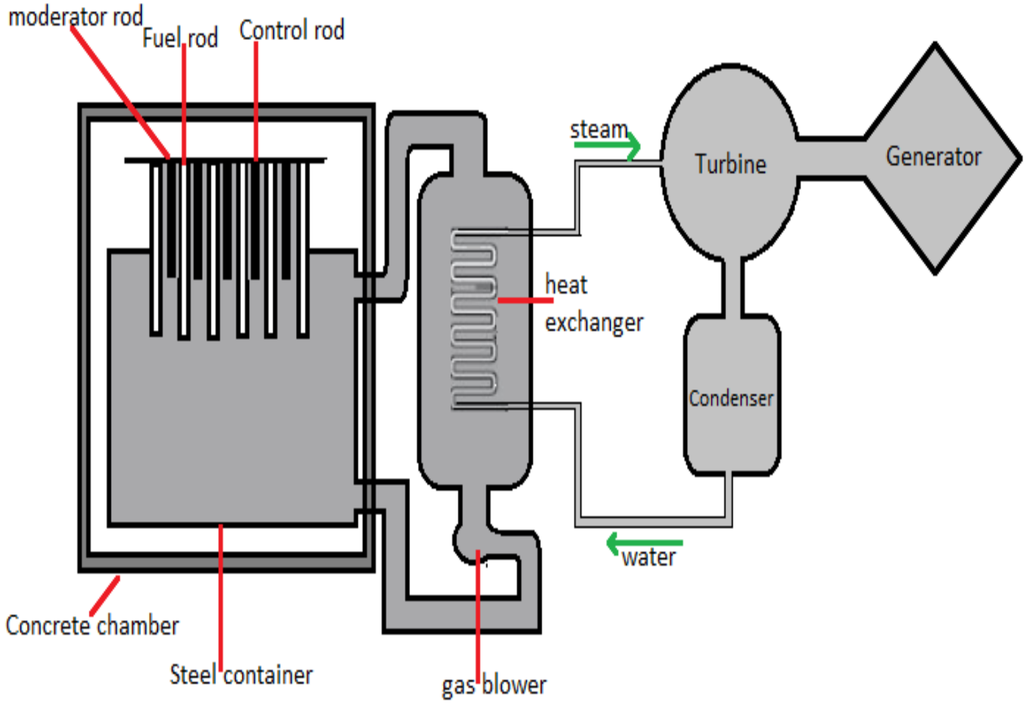
- Nuclear reactor is a system in which the nuclear fission takes place in a self – sustained controlled manner and the energy produced is used either for research purpose or for power generation.
- The first nuclear reactor was built in the year 1942 at Chicago, USA by physicist Enrico Fermi.
- The main parts of the nuclear reactor are the fuel, moderator and control rods.
- In addition to this, there is a cooling system which is connected with the power generation set up.

FUEL

- The fuel is fissionable material, usually uranium or plutonium. Naturally occurring uranium contains only 0.7% of $_{92}U^{235}$ and 99.3% are only $_{92}U^{238}$, so the $_{92}U^{238}$ must be enriched such that it contains at least 2 to 4% of $_{92}U^{235}$.
- In addition to this, a neutron sources is required to initiate the chain reaction for the first time.
- A mixture of beryllium with plutonium or polonium is used as the neutron source.
- During the fission of $_{92}U^{235}$, only fast neutrons are emitted but the probability of initiating fission by in its another nucleus is very low, therefore, slow neutrons are preferred for sustained nuclear reactions.

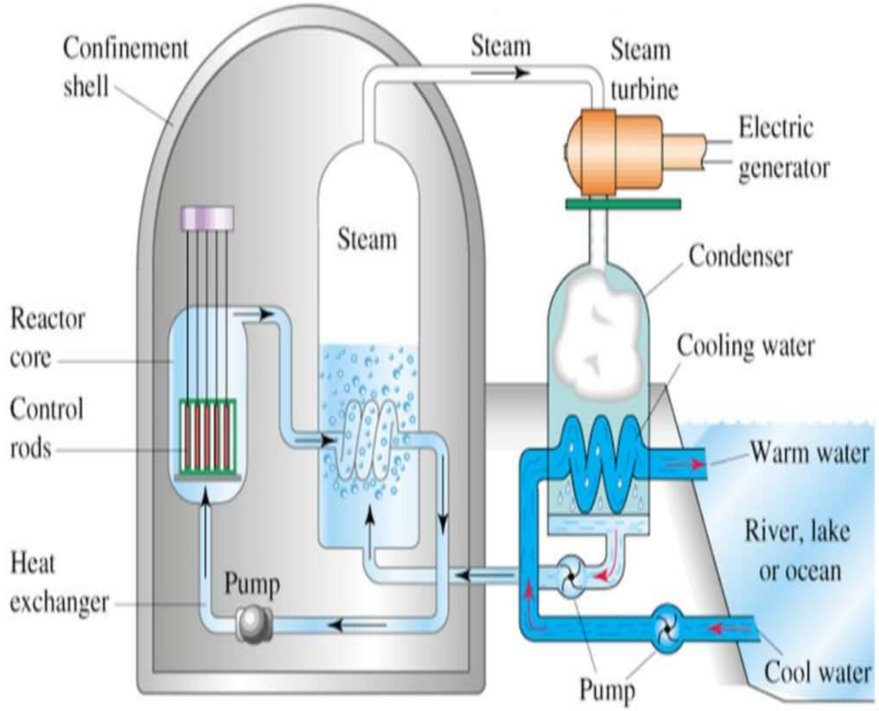
MODERATORS

- The moderators is the material used to convert fast neutrons into slow neutrons. Usually the moderators are chosen in which the way that it must be very light nucleus having mass comparable to that of neutrons.
- Hence, these light nuclei undergo collision with the fast neutrons and the speed of the neutron is reduced.
- Most of the reactor use water, heavy water (D_2O) and graphite as moderators. The blocks of uranium stacked together with blocks of graphite (the moderator) to form a large pile is shown in figure.



CONTROL RODS

- The control rods are used to adjust the reaction rate. During this fission, on an average 2.5 neutrons are emitted and in order to have the controlled chain reaction, only one neutron is allowed to cause another fission and remaining neutrons are absorbed by the control rods.
- Usually cadmium or boron acts as control rod material ad these rods are inserted into the uranium blocks.
- Depending on the insertion depth of control rod into the uranium, the average number of neutrons produced per fission is set to be equal to one, the reactor is said to be in critical state. In fact all the nuclear reactors are maintained in critical state by suitable adjustment of control rods.
- if it is greater than one, the reactor is said to be in super – critical and it may explode sooner or may cause massive destruction.



SHIELDING AND COOLING SYSTEM

SHIELDING

- The production against harmful radiations, the nuclear reactor is surrounded by a concrete wall of thickness of about 2 to 2.5m

COOLING SYSTEM

- The cooling system removes the heat generated in thee reactor core. Ordinary water, heavy water and liquid sodium are used as coolant since they have very high specific heat capacity and large boiling point under high pressure . This coolant passes through the fuel block and carries away the heat to the steam generator through heat exchanger.
- The steam runs the turbines which produces electricity in power reactors.

NUCLEAR REACTOR

NOTE

- India has 22 nuclear reactors in operation.
- Nuclear reactors are constructed in two places in Tamilnadu, Kalpakkam and Kundankulam.
- Even though nuclear reactors are aimed to cater to our energy need, in practice nuclear reactors now are able to provide only 2% of energy requirement of India.

INTERROGATIONS

1. Difference between fission and fusion
2. What are the fissionable materials used in nuclear reactor ?
3. Working principle of moderators
4. What is shielding
5. Principle of cooling system

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THANK YOU