NUCLEAR CHEMISTRY:

Nuclear chemistry is the branch of chemistry that deals changes of matters which are brought about by the nucleus of an atom.

Neutron proton ratio (n/p) determines the stability of the nucleus. For example, in helium the n/p is equal to 1, which makes it stable. But for the elements with higher atomic number, the value of n/p is greater than 1. The stable nuclei fall in the area of graph, which is known as belt of stability. The nuclei lying out of this belt are radioactive.

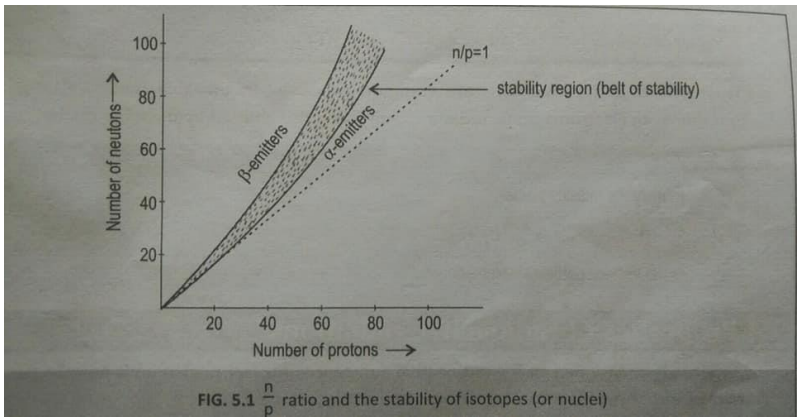

FIG. 5.1 $\frac{n}{p}$ ratio and the stability of isotopes (or nuclei)

The value of n/p ratio determines the fate of elements to be α-particle emitter or β-particle emitter.

1. Emission of α-particle: If n/p ratio in an isotope is lower than that required for stability, it tends to increase the n/p ratio by the emission of α-particle
   For example: ${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$

2. Emission of β-particle: If n/p ratio is greater than that required for the stability, the neutron changes into proton by the emission of β-particle.
   For example: ${}_{0}n^{1} \rightarrow {}_{1}p^{1} + {}_{-1}e^{0}$
   ${}_{6}C^{14} \rightarrow {}_{7}N^{14} + {}_{-1}e^{0}$

Along with α- and β-particles, the unstable nuclei also produce γ-rays. This process of the transformation of a unstable nuclei into the stable one by bombarding it with the particles like α- and β-particles are **artificial radioactivity**.

Differences between α- and β-particles

SN	α-particle	SN	β-particle
1.	The α-particles are the helium nucleus with two protons and two neutrons	1.	The β-particles are an energetic electron
2.	It has 2 units of positive charge.	2.	It has 1 unit of negative charge
3.	It is positively charged helium nucleus	3.	It is negatively charged electrons
4.	Due to larger size, it has low penetrating power	4.	Due to smaller size, it has high penetrating power.
5.	They have very high ionizing power.	5.	They have about 100 times low ionizing power than α-particles

Give any two differences between α- and β-particles

Differences between natural and artificial radioactivity

SN	Artificial radioactivity	SN	Natural radioactivity
1.	The process of emission of radiations from the naturally occurring nuclei when they are bombarded with high energy sub-atomic particles, X-rays or gamma rays	1.	The spontaneous emission of radiation from an unstable nuclei is called natural radioactivity
2.	Artificial radioactive elements usually have short half life.	2.	The element which undergo natural radioactivity usually have long half life.
3.	Artificial radioactivity can be induced even in elements with low atomic numbers	3.	Natural radioactive usually occurs in elements with atomic number greater than 83, which are naturally unstable
4.	${}_{7}N^{14} + {}_{2}He^{4} \rightarrow {}_{9}F^{18} \rightarrow {}_{8}O^{17} + {}_{1}H^{1}$	4.	${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$

Distinguish between artificial and natural radioactivity.

Nuclear reaction:

Nuclear reaction is a type of reaction in which one nuclei can be converted to another new nuclei. In nuclear reaction, one element is converted into another element.

Differences between nuclear reaction and chemical reaction

SN	Nuclear reaction	SN	Chemical reaction
1.	In nuclear reaction, nucleus of the reacting species are involved	**1.**	In chemical reaction, valence electrons of the chemical species are involved.
2.	It does not change with change in temperature, pressure and catalyst.	2.	It changes with the change in temperature, pressure and catalyst.

Give any two differences between nuclear reaction and chemical reaction.

Nuclear fission: A process in which the large nucleus splits into smaller nuclei is called nuclear fission.
For example:
$_{92}U^{235} + {}_{0}n^{1} \rightarrow [\ {}_{92}U^{236}] \rightarrow {}_{56}Ba^{144} + {}_{36}Kr^{90} + 2\ {}_{0}n^{1} + 200Mev$
The fission of uranium produces two energetic neutrons, which initiates the chain reaction and completes with a short span of time, releasing a large amount of energy. This increases the temperature of the surroundings by about million degrees. The energy thus produced is the nuclear energy. This tremendous amount of energy, if controlled by using a moderator, can be used for the commercial power generation. Otherwise, it is used as nuclear weapon.

Nuclear fusion: A nuclear reaction in which more than one lighter nuclei fuse together to form a heavier nucleus, is called nuclear fusion.
For example: $4\ {}_{1}H^{1} \rightarrow {}_{2}He^{4} + 2\ {}_{+1}e^{0} + Energy$
Nuclear fusion is not an easy process because it requires extremely large amount of energy to fuse two lighter nuclei against the nuclear repulsion. The millions of degrees of temperature can only be acquired from nuclear fission. The explosion of hydrogen bomb is due to nuclear fusion reaction.

Differences between controlled and uncontrolled nuclear fission

SN	Controlled nuclear fission	SN	Uncontrolled nuclear fission
1	A nuclear fission reaction, whereby the rate of reaction can be moderated externally, is called controlled nuclear fission.	1	A fission reaction, whereby the rate of reaction can not be moderated externally, is called uncontrolled nuclear fission
2	Controlled nuclear fission is used in commercial power generation	2.	Uncontrolled nuclear fission is used in nuclear weapons

Distinguish between controlled and uncontrolled nuclear fission.

Radioisotopes
Radioisotopes are the isotopes of the same element with different atomic masses, whose nuclei are unstable and dissipate excess energy by spontaneously emitting the radiation in the form of α-, β- and γ- rays.

Application of radioisotopes:

1. They are used in medicine as diagnostic tracers. For example: The radioisotope Iodine-131 is used as tracer to locate malignant cells of thyroid gland
2. Radio isotopes are also used for the treatment of diseases. Iodine-131, in addition of being a tumor marker, can also be used to destroy the malignant cells on the thyroid gland.
3. Cobalt-60 is used in cancer therapy and also in food irradiation.

Write any two applications of isotopes: Cobalt-60 and Iodine-131.