Introduction: -

The study of the nuclear changes in an atom is termed as nuclear chemistry. Nuclear changes are source of radioactivity & nuclear power. That's why nuclear chemistry is very important branch of chemistry.

The process in which atom of one element is converted into atom of another element is called transmutation. Transmutation may take place naturally or brought about artificially. Phenomenon of spontaneous and uncontrollable disintegration occurs by emission of active radiations from an unstable atomic nucleus is called radioactivity. The substance that emits radiations is called radioactive substance.

Nuclear Reaction: -

The reaction in which the nucleus of an atom undergoes transmutation is called nuclear reaction.

$$^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$$

According to Bethe above reaction can be represented as $^{9}Be\ (\alpha, n)\ ^{12}C$.

i.e. Target element (Projectile, Emission) Daughter element.

* The particle used for bombardment in nuclear reaction is called Projectile.
* The element which is bombarded by Projectile is called Target element.
* The product obtained in nuclear reaction is called Recoil nucleus or Daughter element.
* The particle emitted during nuclear reaction is called Emission.

$^{27}Al\ (\alpha, n)\ ^{30}p$, $^{6}Li\ (d, 2\alpha)$

$^{14}N\ (\alpha, p)\ ^{17}O$, $^{10}B\ (n, \alpha)\ ^{7}Li$

$^{23}Na\ (p, \alpha)\ ^{20}Ne$, $^{9}Be\ (\gamma, n)\ ^{8}Be$

Energetic of Nuclear Reaction: - Nuclear Reactions associated with gain or loss of energy.

Nuclear Reaction in which energy is absorbed is called endoergic nuclear reaction.

$$e.g.\ ^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H + 4.0\ MeV$$

Nuclear Reaction in which energy is released is called exoergic nu reaction.

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H - 1.16\ MeV.$$

In Nuclear Reaction change in energy is large and calculated by Einstein equation. $E = m C^2$

1 amu = 931 MeV 1 MeV = 9.648×10^7 KJ/mol

Types of Nuclear Reaction: -

1) Artificial Transmutation 2) Natural Transmutation

1) Artificial Transmutation

i) Artificial Transmutation or Artificial disintegration: -

When the transmutation is done by artificial means is called Artificial Transmutation or disintegration.

Or the conversion of one element into another element by artificial means is called Artificial Transmutation or disintegration.

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$$

First Artificial Transmutation was recognized, described and reported by Rutherford in 1919.

E.g. Using various projectiles various transmutations are carried out as

(a) Transmutation by α-particles

(α, n) process :

(i) $^{9}_{4}B + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$

(α, p) process :

(i) $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$

(ii) $^{19}_{9}F + ^{4}_{2}He \rightarrow ^{22}_{10}Ne + ^{1}_{1}H$

(iii) $^{31}_{15}P + ^{4}_{2}He \rightarrow ^{34}_{16}S + ^{1}_{1}H$

(b) Transmutation by deuterons

(d, α) process :

(i) $^{6}_{3}Li + ^{2}_{1}H \rightarrow 2\,^{4}_{2}He$

(ii) $^{14}_{7}N + ^{2}_{1}H \rightarrow ^{12}_{6}C + ^{4}_{2}He$

(iii) $^{27}_{13}Al + ^{2}_{1}H \rightarrow ^{25}_{12}Mg + ^{4}_{2}He$

(d, n) process :

(i) $^{27}_{13}Al + ^{2}_{1}H \rightarrow ^{28}_{14}Si + ^{1}_{0}n$

(c) Transmutation by protons

(p, α) process :

(i) $^{9}_{4}Be + ^{1}_{1}H \rightarrow ^{6}_{3}Li + ^{4}_{2}He$

(ii) $^{7}_{3}Li + ^{1}_{1}H \rightarrow 2\,^{4}_{2}He$

(d) Transmutation by gamma rays

(γ, n) process :

(i) $^{9}_{4}Be + \gamma \rightarrow ^{8}_{4}Be + ^{1}_{0}n$

(e) Transmutation by neutrons

(n, α) process :

(i) $^{10}_{5}B + ^{1}_{0}n \rightarrow ^{7}_{3}Li + ^{4}_{2}He$

(ii) $^{16}_{8}O + ^{1}_{0}n \rightarrow ^{13}_{6}C + ^{4}_{2}He$