Nuclear Reactions.

The process by which the identity of a nucleus is changed when it is bombarded by an energetic particle is called nuclear reaction. The general expression for the nuclear reaction is as follows.

$$\underset{\text{(Parent nucleus)}}{X} + \underset{\text{(Incident particle)}}{a} \longrightarrow \underset{\text{(Compound nucleus)}}{C} \longrightarrow \underset{\text{(Compound nucleus)}}{Y} + \underset{\text{(Product particles)}}{b} + \underset{\text{(Energy)}}{Q}$$

Here X and a are known as reactants and Y and b are known as products. This reaction is known as (a, b) reaction and can be represented as X(a, b) Y

(1) Q value or energy of nuclear reaction

The energy absorbed or released during nuclear reaction is known as Q-value of nuclear reaction.

Q-value = (Mass of reactants – mass of products) c2 Joules

= (Mass of reactants – mass of products) amu

If Q < 0, The nuclear reaction is known as endothermic. (The energy is absorbed in the reaction)

If Q > 0, The nuclear reaction is known as exothermic (The energy is released in the reaction)

(2) Law of conservation in nuclear reactions

(i) Conservation of mass number and charge number: In the following nuclear reaction

$${}_2He^4 + {}_7N^{14} \rightarrow {}_8O^{17} + {}_1H^1$$

Mass number (A) → before the reaction after the reaction

4 +14 = 18 17 + 1 = 18

Charge number (Z) → 2 + 7 = 9 8 + 1 = 9

(ii) Conservation of momentum: Linear momentum/angular momentum of particles before the reaction is equal to the linear/angular momentum of the particles after the reaction. That is Σp = 0

(iii) Conservation of energy: Total energy before the reaction is equal to total energy after the reaction. Term Q is added to balance the total energy of the reaction.

(3) Common nuclear reactions

The nuclear reactions lead to artificial transmutation of nuclei. Rutherford was the first to carry out artificial transmutation of nitrogen to oxygen in the year 1919.

$${}_2He^4 + {}_7N^{14} \rightarrow {}_9F^{18} \rightarrow {}_8O^{17} + {}_1H^1$$

It is called (α, p) reaction. Some other nuclear reactions are given as follows.

(p, n) reaction ⇒ $_1H^1 + {}_5B^{11} \rightarrow {}_6C^{12} \rightarrow {}_6C^{11} + {}_0n^1$

(p, α) reaction ⇒ $_1H^1 + {}_3Li^{11} \rightarrow {}_4Be^8 \rightarrow {}_2He^4 + {}_2He^4$

(p, γ) reaction ⇒ $_1H^1 + {}_6C^{12} \rightarrow {}_7N^{13} \rightarrow {}_7N^{13} + \gamma$

(n, p) reaction ⇒ $_0n^1 + {}_7N^{14} \rightarrow {}_7N^{15} \rightarrow {}_6C^{14} + {}_1H^1$

(γ, n) reaction ⇒ $\gamma + {}_1H^2 \rightarrow {}_1H^1 + {}_0n^1$