Marwari college Darbhanga

Subject---physics Hons

Class--- B. Sc. Part 3

Paper -06 ; Group—A

Topic--- Conservation Laws in Nuclear Reactions(Nuclear Physics)

Lecture series -- 75

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Conservation Laws in Nuclear Reactions

1. **Conservation of nucleons**. The total number of nucleons before and after a reaction are the same.
2. **Conservation of charge**. The sum of the charges on all the particles before and after a reaction are the same

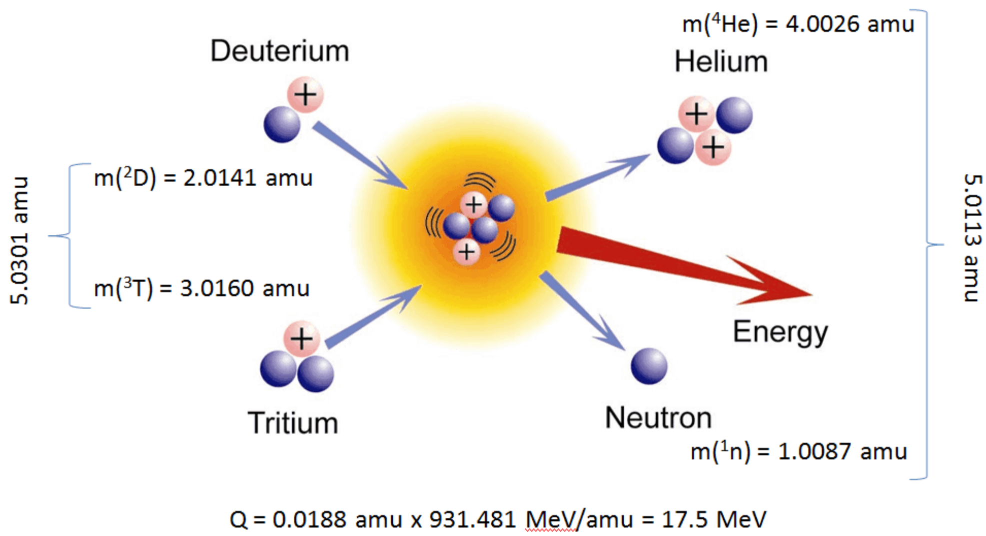
3. **Conservation of momentum**. The total momentum of the interacting particles before and after a reaction are the same.
4. **Conservation of energy**. Energy, including rest mass energy, is conserved in nuclear reactions.

Conservation of Energy in Nuclear Reactions

In analyzing nuclear reactions, we have to apply the general law of conservation of mass-energy. According to this law mass and energy are equivalent and convertible one into the other. It is one of the striking results of Einstein's theory of relativity**.** This equivalence of the mass and energy is described by Einstein's famous formula $\mathbf{E = mc^2}$.

Generally, in both chemical and nuclear reactions, some conversion between rest mass and energy occurs, so that the products generally have smaller or greater mass than the reactants. In general, the total (relativistic) energy must be conserved. The "missing" rest mass must therefore reappear as kinetic energy released in the reaction. The difference is a measure of the nuclear binding energy which holds the nucleus together.

The nuclear binding energies are enormous, they are of the order of a million times greater than the electron binding energies of atoms.



Q-value of Q DT fusion reaction

The energetics of nuclear reactions is determined by the **Q-value** of that reaction. The **Q-value** of the reaction is defined as the difference between the sum of the masses of the initial reactants and the sum of the masses of the final products, in energy units (usually in MeV).
Consider a typical reaction, in which the projectile a and the target A gives place to two products, B and b. This can also be expressed in the notation that we used so far, **a + A** → **B + b**, or even in a more compact notation, **A(a,b)B**.

The Q-value of this reaction is given by:

$$Q = [m_a + m_A – (m_b + m_B)]c^2$$

which is the same as the excess kinetic energy of the final products:

$$Q = T_{final} - T_{initial}$$
$$= T_b + T_B - (T_a + T_A)$$

For reactions in which there is an increase in the kinetic energy of the products Q is positive. The positive Q reactions are said to be exothermic (or exergic). There is a net release of energy, since the kinetic energy of the final state is greater than the kinetic energy of the initial state. For reactions in which there is a decrease in the kinetic energy of the products Q is negative. The negative Q reactions are said to be endothermic (or endoergic) and they require a net energy input.

The energy released in a nuclear reaction can appear mainly in one of three ways:

- **Kinetic energy** of the products
- **Emission of gamma rays**. Gamma rays are emitted by unstable nuclei in their transition from a high energy state to a lower state known as gamma decay.
- **Metastable state**. Some energy may remain in the nucleus, as a metastable energy level.
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A small amount of energy may also emerge in the form of X-rays. Generally, products of nuclear reactions may have different atomic numbers, and thus the configuration of their electron shells is different in comparison with reactants. As the electrons rearrange themselves and drop to lower energy levels, internal transition X-rays (X-rays with precisely defined emission lines) may be emitted.