(1)

Nature of nuclear force:-

Nuclear force (also known as nuclear interactions or strong forces) is the forces that act between two or more nucleons. They bind proton and neutrons (nucleons) into atomic nuclei. The nuclear force is about 10 millions times stronger than the chemical binding that hold together in molecule.

Nuclear forces have the following properties.

- The strong nuclear force binds protons and neutrons in a nucleus.
- Strong nuclear force is the strongest force in nature
- It is a short range force and is operative only over the size of nucleus.
- strong nuclear force responsible for the stability of nuclei.

Nuclear forces are non-central forces. i.e the force between two nucleons does not act along in the joining their centre. This shows that nucleons in the nucleus is not spherically symmetric.

Properties of nuclear forces:-

1. It is attractive in nature but with a repulsive core. That is the reason that the nucleus is held together without collapsing in itself.
2. The range of nuclear force is very short. At 1 fermi the distance between particles in a nucleus is tiny. At this range the nuclear force is much stronger than the repulsive Coulomb's force that pushes the particles away. However, if the distance is anything more than 2.5 Fermi, nuclear force is practically non-~~existeate~~ existent.
3. The nuclear force is identical force is identical for all nucleons. It does not matter ~~it is a matter~~ it is a neutron or proton, once the Coulomb resistance is taken into consideration, nuclear force affects every thing in the same way.

At a distance of less than 0.7 Fermi, this force becomes repulsive. It is one of the most interesting properties of nuclear force as this repulsive component of the force is what decides the size of the nucleus. The nucleons come closer to each other till the point that the force allows, after which they can not come closer because of the repulsive property of the force.

General properties of nucleus:—

Some of the important properties of atomic nucleus:—

(i) Nuclear mass:— Nuclear mass means the mass or weight of the nucleus proper. But is often called the atomic mass number (or atomic weight) which would rather imply the mass or weight of the whole atom. The mass of the nucleus is equal to the sum of the masses of neutrons and protons, each of which has a mass nearly unity or 1 atomic mass unit. Accordingly the C^{12}_{6} nucleus has a mass of 12 amu so that its mass number $A = 12$. Similarly the uranium nucleus U^{238}_{92} has a mass of 238 amu.

(ii) Nuclear charge:—
The number of units of positive charge carried by a nucleus is equal to the number of its protons. Hence charge equals its atomic number Z. For example a hydrogen nucleus (i.e. proton) carries a single positive charge ~~whereas~~ whereas nobelium nucleus carries 102 units of positive charge.

(iii) Nuclear Radius:—
Nuclear radii have been calculated from observations on the maximum scattering angles of α-particles as well as scattering on other particles like protons and neutrons by various target nuclei. According to Rutherford calculation, greater the angle through which an α-particles has been deflected, the closer has its approached the atomic nucleus before being turned away. By measuring the maximum scattering angle the distance

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of the closer approach between the centre of an atom nucleus and an α-particle can be calculated. This distance, of the order of 10^{-14} m., represents the maximum value for the sum of the radii of an atomic nucleus and an α-particles. The radius of an atomic nucleus is given by $R = R_0 A^{1/3}$ where R_0 has an average value of 1.4×10^{-15} m.

$\therefore R = 1.4 \times 10^{-15} \times A^{1/3}$.

For carbon $A = 12$

$\therefore R = 1.4 \times 10^{-15} \times 12^{1/3} = 3.21 \times 10^{-15}$ m.

For uranium $A = 238$

$\therefore R = 1.4 \times 10^{-15} \times 238^{1/3} = 8.68 \times 10^{-15}$ m.

(IV) Nuclear density:-

Since size of the nucleus is extremely small and its mass very large, its density is fantastically high. The density of all nuclei is found to be about the same and equal to almost 10^{7} kg/m. Obviously the nuclear density is much higher than that of the matter in bulk which must be comparatively very porous. On the basis of ~~eq~~ equivalance of mass and energy, it is seen that the concentration of energy is much greater in nuclei than in bulk material.

(V) Nuclear quantum state.

The study of α and γ-rays spectra as well as artificial radioactivity shows that every nucleus possesses a set of quantum states and a corresponding number of discrete energy levels. Transitions between different nuclear states are accompanied by emission of γ-rays. There is great resemblance between quantum states in side the nucleus and those in the extranuclear or orbital electrons. But there is a fundamental ~~differen~~ difference as regards the nature of the forces acting in their respective regions. In the extranuclear region, the Coulomb's law of inverse square reign supreme whereas inside the nucleus, some other law of short-range nuclear forces comes into play.

Nuclear spin and magnetic moment:-

Since a nucleus has finite size, it possesses, just like orbital electron, spin motion and the consequent magnetic moment. Experimental evidence shows that the constituent particles inside the nucleus are in continuous motion in discrete quantized orbits. This orbital motion endows the nucleus with mechanical angular momentum because of which protons additionally possess magnetic moment, over and above these orbital motion the nuclear particles spin about their own axes and so possess spin angular momentum and an associated magnetic moment. Hence the nucleus as a whole will possess the following.

(i) resultant angular momentum which is the resultant of the orbital and spin moment of different constituent particles. It is refered to as nuclear spin.

(ii) resultant angular momentum called nuclear magnetic moment which is the resultant of the moments due to the orbital and spin motion of protons inside the nucleus.

The nuclear spin or angular momenta of nuclei in general is given by $p_i = I\frac{h}{2\pi}$

where I is the nuclear spin quantum number. This quantum number I has half-integral values for all isotopes of odd mass numbers and whole number or integral values for all those with even mass numbers.

For all nuclei, the magnetic moment is given by

$\mu_I = g\frac{h}{2\pi}\frac{e}{2M}$ where g-factor varies from nucleus to nucleus and M is the mass of proton. The product $\frac{h}{2\pi}\cdot\frac{e}{2M}$ is known as nuclear magneton.

i.e $\mu_n = \frac{h}{2\pi}\cdot\frac{e}{2M} = 5.05\times10^{-27}$ A·m.

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