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Electric Charge :-

An electric charge is defined as the physical quantity characterising the property of bodies or particles to enter into electromagnetic interactions and determine the values of the forces and ~~eng energing~~ energies in such interactions. Electric charges can be positive and negative. A positive charge on amber rubbed with fur. Elementary particles and their anti-particles are stable carriers of electric charges. A proton and a positron carry a positive charge an electron and an antiproton carry a negative charge.

Conservation and Quantisation of Physical quantities :-

When a physical quantity in an isolated system does not change as a result of some process taking place in the system, then the quantity is said to be conserved. For example, when two moving bodies collide with each other elastically, the energy as well as the momentum of the system remains unchanged. This shows that the energy and momentum both are conserved.

Similarly, when a physical quantity exists in discrete packets rather than in continuous amounts, the quantity is said to be quantised for example the energy in a beam of monochromatic radiation comes in packets of $h\nu$ where ν is frequency and h is plank's constant. Thus, the radiant energy is quantised. The ~~eg~~ angular momentum and energy of an electron moving in an orbit in the ~~amounts~~ atom are also quantised. In fact the quantisation is a basis of modern physics.

The electric charge shows both these properties. — It is conserved as well as quantised.

Conservation of charge :-

Experiments shows that the total electric charge in an isolated system never changes. No exception to this has ever been found. Following are the few processes which show that charge is conserved.

i) When a glass rod is rubbed with silk a positive charge appears on the rod and at the same time an equal negative charge appears on the silk. Thus the net charge on the rod-silk system is zero both before and after rubbing.

ii) When an energetic γ- ray photon $(q=0)$ collides with the electric field inside an ~~amount~~ atom it is converted into an electron of charge $(-e)$ and a positron of charge $(+e)$

$$h\nu = e^- + e^+ \text{ (pair production)}$$

Again the net charge is zero both before and after the event. Conversely when an electron and positron collide they disappear leaving electromagnetic radiation in the form of γ. rays. The rest mass is not conserved because it is converted completely into radiation.

iii) When two high energy protons each having charge $+e$ collide it may happen that the two protons remain after the collision with reduced energy and two π- mesons appear. One carrying a charge $+e$ and the other a charge $-e$.

$$P + P \longrightarrow P + P + \pi^+ \ \pi^-$$

The total charge is $+2e$ both before and after the collision

iv) In radioactive decay the uranium nucleus (charge $= +92e$) is converted into a Thorium nucleus (charge $= +90e$) and emits an α- particle of charge $= +2e$.

$$_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}.$$

Thus the total charge is $= +92e$ both before and after the decay.

The final example of charge conservation is the nuclear reactions. such as proton and α-particle reactions given below.

$$_{80}Hg^{200} + {}_{1}H^{1} = {}_{79}Au^{197} + {}_{2}He^{4}$$

Mercury proton Gold α-particle.

Thus we again see that amount of charge (81e) present before and after disintegration is the same.

So, we can conclude the electric charges can be only separated or combined when positive and negative charge appear or disappear in equal quantities. Therefore the charge conservation law is that the total electric charge in an isolated system never changes.

Quantisation of Charge:-

Today the electric charge like other physical quantities such as energy and angular momentum in the orbit is not regarded as a continuous fluid. Millikan's oil drop experiment has proved that the electric field is not continuous but it is made up of integral multiples of a certain minimum electric charge. This minimum electric charge is denoted by 'e' the electronic charge has the magnitude of 1.6×10^{-19} Coulomb. Any physically existing charge in the universe is an integral multiple of 'e' (i.e. ne) irrespective of its origin. So that the charge exists in discrete packets rather than in continuous amount. This is referred as charge quantisation.

However, the fact of charge quantisation lies outside the scope of classical electromagnetism. The question that how this electronic charge is continued i.e. what is the force which holds the electrons together or how the precise value of its charge is fixed. Something more than electrical forces must be involved. because the electrostatic forces between the different parts of the electron would be repulsive.

Very sensitive experiments have been conducted recently to measure the ratio of the charge of electron to the charge of proton. It has been found that this ratio is equal to -1 to an accuracy of one part in 10^{20}. Similarly it has been found that the ratio of charge of the helium necleus to the charge of the electron is equal to -2 to the same accuracy. This too establishes the quantisation of charge.