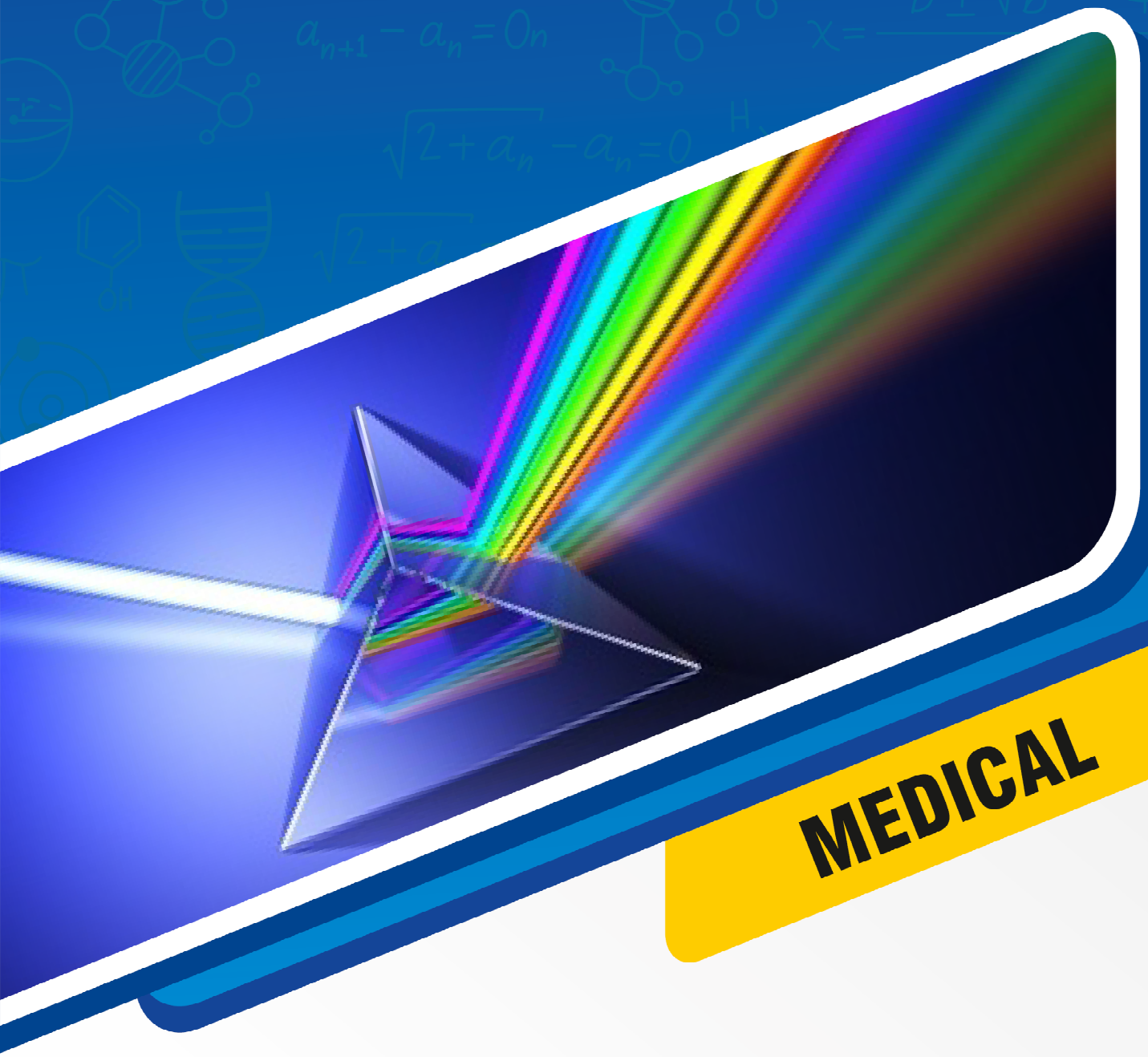
PHYSICS



MEDICAL

ELECTROSTATICS

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CONTENT

ELECTROSTATICS

Electrostatics

Syllabus (NEET + UG) :

- Electric charges and their conservation , Coulomb's law - force between two point charges, Force between multiple charges ; Superposition principle and continous charge distribution.
- Electric field, Elecric field due to a point charge, Electric field lines Electric dipole, Electric field due to a dipole; Torque on a dipole in a uniform electric field.
- Electric flux, Statement of Gauss's theorem and its application to find field due to infinitely long straight wire, Uniform charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside)
- Electric potential, potential difference ,Electric potential due to a point charge, A dipole and a system of charge , Equipotential surfaces; Electric potential energy of a system of two point charges and of electric dipole in an electrostatic field.
- Conductor and insulator; free charge and bound charge inside a conductor. Dielectric and electric polarization, Capacitors and capacitance, Combination of Capacitor in series and parallel, Capacitance of a parallel plate capacitor with and without dielectric medium between the plates , Energy stored in a capacitor, Van de graff generator.

Electrostatics is the branch of physics in which we study charge at rest.

CHARGE :

It is the inherent property of substance by virtue of which it attract or repel another substance.

Charges are of two types.

(a) Positive charge : Lesser number of electrons than number of protons.

(b) Negative charge : More number of electrons than number of protons

Important Points : Only electron is responsible for a substance to be charged and not the proton.

Properties of Charge :

(i) Like charges repel while unlike charges attract each other.

(ii) Charge is quantized in nature i.e. The magnitude of charge possessed by different objects is always an integral multiple of charge of electron (or proton) i.e. $q = \pm ne$ where $n = 1 , 2 , 3 .....$

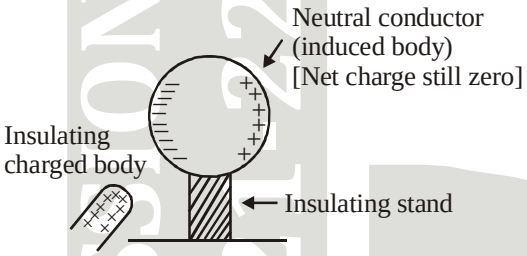
(iii) The minimum possible charge that can exist in nature is the charge of electron which has a magnitude of $e = 1.60\ 207 \times 10^{-19}$ coulomb. This is also known as quantum of charge or fundamental charge.

(iv) In an isolated system the algebraic sum of total charge remains constant. This is the law of 'Conservation of charge'.

☞ ***The fact that electric charge is an integral multiple of electronic charge was experimentally proved by Milliken. Unit of charge $\rightarrow$ 1 coulomb = 3×10^9 e.s.u. = 1/10 e.m.u., in cgs $\rightarrow$ e.s.u. (state coulomb)***

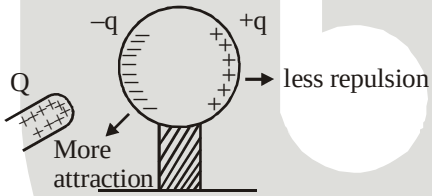
ELECTROSTATIC INDUCTION :

When a charged body is brought near a neutral body, charged body attracts opposite charge and repels similar charge present in the neutral body. As a result of this, one side of the neutral body becomes excess in positive charge while the other side becomes excess in negative charge. (However the total sum of charges in the neutral body is still zero). This process is called electrostatic induction.



The induced charge near to the charged inducing body is always opposite in nature. The amount of charge of the inducing body is not affected by the process of induction.

There is always a force of attraction between the inducing (charged) body and induced (neutral) body. Because the induced opposite charge is closer to the inducing body. Say, the inducing charge is Q and the induced charges are – q and + q, as shown below. You can see + Q and – q are closer than + Q and + q, hence attraction will be more between + Q and – q compared to repulsion between + Q and +q.



You remember, we stated earlier that opposite charges attract each other, but if there is attraction between two bodies do not jump to the conclusion that they are always oppositely charged.

When a comb is run in dry hair, it starts attracting small pieces of paper, which after touching the comb, often jump violently away from it. The reason is that when comb is run in dry hair, it gets charged due to friction. Now when it is brought close to the piece of paper it will attract, as we explained there is a force of attraction between a charged and a neutral body. Now after the paper is touching the comb, the charge of comb is shared by the paper and both have similar charge now. As you know, similar charges repel so the piece of paper gets repelled now in the form of violent jump.

Illustration :

Two spheres of the same metal (in all respects) are taken. One is given a positive charge of Q coulomb. and other is given the same but negative charge. Which sphere will have a higher mass.

Sol. *Negatively charged sphere will have a higher mass. This is due to increase in number of electron to make it negatively charged.*

Illustration :

Which charge has a higher value + 4c or – 4c.

Sol. *Same for both because + ve or – ve sign represents only opposite nature.*

Illustration :

Which of the following charge is not possible?

(1) $1.6 \times 10^{-18}c$ (2) 1.6×10^{-19} c (3) 1.6×10^{-20} c (4) None of these

Sol. *1.6×10^{-20} c, because this is 1/10 of electronic charge and hence not an integral multiple.*

Illustration :

How many electron are present in 1 coulomb charge ?

Sol. $\therefore$ $q = ne$

$q = 1c$

$e = 1.6 \times 10^{-19}$ c

$n = ?$

$n = q/e = 6.25 \times 10^{18}$ electrons.

Illustration :

Which is true test of charge on the body attraction or repulsion?

Sol. *Repulsion. A charged body and an uncharged body can attract each other due to induction.*

Illustration :

Calculate protonic charge in 100 cc of water.

Sol. *1 cc = 1 gm for water as density = 1 gm/cm^3*

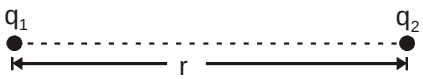
Now number of atoms in 18 gm (atm weight) = 6.023×10^{23} and each molecule of H_2O contains 10 proton (8 of oxygen + 2 of H_2)

so number of proton in 100 gm water = $\left(\frac{6.023\times10^{23}}{18}\times100\right)\times10 = 3.3\times10^{25}$

hence protonic charge = $3.3 \times 10^{25} \times 1.6 \times 10^{-19} = 5.4 \times 10^{6}$ C.

COULOMB'S LAW :

The force of attraction or repulsion between two stationary point charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of distance between them. This force acts along the line joining the two. If q_1 & q_2 are charges in consideration and r the distance between them and F is the force acting between them.



Then , $F \propto q_1 q_2$

$F \propto 1/r^2$

$\therefore$ $F \propto \frac{q_1 q_2}{r^2}$