Chapter: 1

Electric Charges and Fields

Q 1. When two charges experience a force F in a vacuum, how does inserting a brass rod between them alter this force?

Ans. For any metal, K=∞

$F_{brass} = f_{vac}/K = F/\infty = 0$

i.e. in the presence of a brass rod the force between the two charges becomes zero.

Q.2. Describe what is meant by the statement 'the electric charge of an object is 'quantized' in nature.'

Ans. Electric charge of a body is quantized. This means that only the integral (1, 2, ..., n) number of electrons can be transferred from one body to the other. Charges are not transferred in fraction. Hence, a body possesses total charge only in integral multiples of electric charge.

Q.3. Explain the importance of Gauss's theorem?

Ans. Gauss' theorem holds immense importance, particularly in scenarios where computing the electric field using Coulomb's law of superposition principles becomes exceedingly complex. In such cases, Gauss's theorem offers a straightforward method to obtain results with considerable ease.

Q.4. What is electric flux? A charge q is enclosed by a spherical surface of radius R. If the radius is reduced to half, how would the electric flux through the surface change?

Ans. Electric flux is a measure of the electric field passing through a given surface. It quantifies the number of electric field lines passing through a surface. Its SI unit is the volt-meter ($V \cdot m$) or the newton-meter squared per coulomb ($N \cdot m^2/C$).

If a charge q is enclosed by a spherical surface of radius R and the radius is reduced to half, the electric flux through the surface would change. As the surface area decreases when the radius is halved, the electric flux would also decrease since there are fewer field lines passing through the smaller surface.

Q.5 A polythene piece rubbed with wool is found to have a negative charge of 3×10^{-7} C.

(a) Is there a transfer of mass from wool to polythene?
(b) Estimate the number of electrons transferred (from which to which?).
Ans. When two neutral bodies are rubbed together, electrons of one body are transferred to the other. The body which gains electrons is negatively charged and the body which loses electrons is positively charged.

(a) Yes, as electrons have finite mass, the mass is transferred from wool to polythene.
$M = n \times m = 1.875\ 10^{12} \times \times 9.1 \times 10^{-31} = 1.7 \times 10^{-18}$ kg

(b) From quantisation of charge q = ne
Here, $q = 3 \times 10^{-7}$C and $e = 1.6 \times 10^{-19}$C
∴ Number of electrons transferred, n = q/e
=
$3 \times 10^{-7}/1.6 \times 10^{-19} = 1.875 \times 10^{12}$

When polythene is rubbed with wool, the polythene becomes negatively charged and wool becomes positively charged. This implies that the electrons are transferred from wool to polythene.

Q.6.What is the difference between a sheet of charge and a plane conductor having charge?
Ans. On a sheet of charge, the same charge shows up on its two sides; whereas in case of a charged plane conductor, the charges showing up on the two surfaces are not the same.

Q.7. What is a Gaussian surface? What purpose does it serve?
Ans. A Gaussian surface is an imaginary closed surface used in physics to simplify calculations of electric fields. It encloses a charge or a distribution of charges, allowing application of Gauss's law to determine electric flux. It aids in deriving relationships between charges and electric fields for various symmetrical systems, simplifying complex calculations.