Problems on charged sphere and energy conservation

Problems on charged spheres and energy conservation" refers to exercises or questions that involve scenarios with charged spheres and require the application of principles related to the conservation of energy. These problems typically involve situations such as calculating electric fields, potentials, charges, or energies associated with charged spheres, while also ensuring that energy is conserved throughout the process.

Energy conservation in E-field

"Energy conservation in the electric field" refers to the principle that the total energy within an electric field remains constant over time, provided there is no external influence. This principle is derived from the conservation of energy, which states that energy cannot be created or destroyed, only transformed from one form to another. In the context of electric fields, energy conservation is often applied to analyze the distribution of electric potential energy, kinetic energy of charges, and work done by electric forces within the field.

Ex. Consider a solid non-conducting sphere with a radius R and a charge density ρ=ρ0r C/m^3, as depicted. Determine the electric field E at a distance r from the center.

Sol. In this scenario, the charge density varies. To calculate the electric field at a distance r (where r < R) using Gauss' theorem, it's necessary to determine the total charge enclosed by a Gaussian sphere with a radius r. To ascertain the total charge within the Gaussian sphere, we examine an elementary shell with a radius x and a thickness dx. Hence, the charge of the elementary shell is:

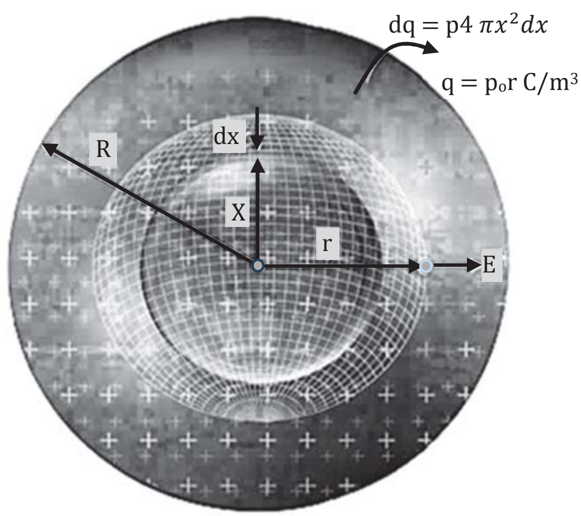
$$dq = \rho(x) 4\pi x^2 dx$$

Hence, the sum of all charges contained within the Gaussian surface is:

qin = $\int dq = \int p(x) \cdot 4\pi x^2 dx$

qin = $\int dq = p_o . 4\pi \int_o x^3 dx$ (Since p(x) = $p_o x$)

qin = $P_o \pi r^4$



Gauss' theorem,

$$\oint \vec{E} \cdot \overrightarrow{dA} = q_m/\varepsilon_0$$

$$E \cdot 4\pi r^2 = \frac{q_{in}}{\varepsilon_0}$$

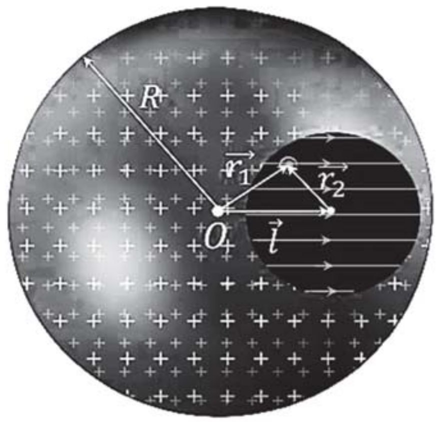
$$E \cdot 4\pi r^2 = \frac{p_0 \pi r^4}{\varepsilon_0}$$

$$E = \frac{p_0 r^2}{4\varepsilon_0}$$

Electric Field Inside the Cavity

The electric field within the cavity maintains a consistent magnitude and direction, expressed as: $\vec{E}_{\text{net}} = \frac{\rho\vec{l}}{3\varepsilon_0}$

The orientation of the electric field within the cavity aligns with the direction of the position vector, denoted as $\vec{l}$



Cavities inside conducting sphere

Cavities inside a conducting sphere refer to empty spaces or voids within the interior of a spherical conductor. Conducting spheres are solid objects made of conductive materials such as metal, and they possess the property of charge distribution where charges reside on the surface. When a conducting sphere contains cavities, these cavities do not affect the distribution of charge on the outer surface of the sphere due to the conductive nature of the material. As a result, the electric field within the cavities is zero, and any charges placed inside the cavities redistribute themselves to the outer surface of the sphere. The study of cavities within conducting spheres is important in understanding electrostatic phenomena and the behavior of charges in conductive materials.