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HA-1

Q The volume charge density inside a hollow sphere is $\rho = 10e^{-20r}$ C/m³. Find the total charge enclosed with the sphere. Also find the electric flux density on the surface of the sphere.

A ~~The electric flux~~

① Total charge enclosed is given by

$$Q = \int \rho \, dv$$

$$= \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} \int_{r=0}^{2} e r^2 \sin\theta \, dr \cdot d\theta \cdot d\phi$$

$$= \int_0^{2\pi} d\phi \int_0^{\pi} \sin\theta \, d\theta \int_0^{2} (10 e^{-20r}) r^2 dr$$

$$= \pi/100 \ C$$

also $Q_{enc} = \oint_s D \cdot dS$

$$D(R) \cdot 4\pi R^2 = Q_{enc}$$

$$D(R) = Q/4\pi r^2 = 0.25 \times 10^{-14} \ C/m^2$$

② We know

$$\nabla \cdot \vec{D} = \rho$$

$$\frac{\delta \vec{D}_x}{\delta x} + \frac{\delta \vec{D}_y}{\delta y} + \frac{\delta \vec{D}_z}{\delta z} = \rho$$

$$\frac{\delta (x^2)}{\delta x} + \frac{\delta (xy)}{\delta y} + \frac{\delta (x^2 y^2)}{\delta z} = \rho$$

$$2x + x = \rho$$

$$3x = \rho$$

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$x = -2$ to 2

$$Q = \int_{-2}^{2} \int_{-2}^{2} \int_{-2}^{2} 3x \, dx \, dy \, dz$$

$$Q = \left[\frac{3x^2}{2}\right]_{-2}^{2} [y]_{-2}^{2} [z]_{-2}^{2}$$

$$Q = 0$$

③ The curl of gradient is zero. This is fundamental property in vector

$$\nabla \times (\phi) = 0$$

Gradient of scalar field:

$$\nabla \phi = (d\phi/dx, \ d\phi/dy, \ d\phi/dz)$$

Curl

$$\nabla \times F = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ d/dx & d/dy & d/dz \\ d\phi/dx & d\phi/dy & d\phi/dz \end{vmatrix}$$

$$= 0$$