Quiz 11 Gauss's law

Question 1. A spherical conductor has a radius of 0.04 m. On the surface an amount of charge is evenly distributed with a surface charge density of $\sigma = 6.5$ nC/m^2. What is the strength of the electric field at the surface of this conductor?

Correct answer:

$734 \frac{N}{C}$

Explanation:

Gauss's law tells us that electric field strength is equal to the enclosed charge divided by the vacuum permittivity, ϵ_0, and the area of the Gaussian surface. Taking a Gaussian surface at (or just over) the surface of the sphere gives our Gaussian area the same area as the sphere. The amount of charge is the surface charge density, σ, times the area of the sphere.

$$Q = \sigma A$$

$$E = \frac{Q}{\epsilon_0 A}$$

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$$E = \frac{\sigma}{\epsilon_0} = \frac{6.5 \cdot 10^{-9}}{8.85 \cdot 10^{-12}} = 734 \frac{N}{C}$$

Question 2. Imagine a spherical conducting shell of inner radius *a* and outer radius *b*. If there exists a point charge of 5Q at a radius of less than *a* (it sits within the void inside the conducting shell), and the total charge of the conducting shell is 3Q, what is the magnitude of the charge on the outer surface of the shell?

Explanation:

The main property of a conductor is that the electric field inside the material is zero. So if there is 5Q point charge within the void of the conductor, $-5Q$ must sit on the inner surface of the conductor(at radius a). The conductor will put the $-5Q$ here in order to ensure that the electric field inside the material is zero. This follows from Gauss' law that says the strength in the electric field is directly related to how much charge is contained within the Guassian surface. The only way to enclose zero charge while a point charge of 5Q exists is to cancel it out with $-5Q$ on the inner surface of the conductor. Also note that charges only can exist on the surfaces of the conductors, not within. So if the overall charge of the shell is 3Q, then a total charge of 8Q must reside on the outer surface of the conducting shell.

$$8Q + (-5Q) = 3Q$$