A solid sphere of radius 3m has a charge of $108\pi$ C uniformly distributed throughout its volume. (leave your answers in terms of $\varepsilon_0$ & $\pi$ treated as numbers without units, do not forget to put units on your final answers)

a. Is this sphere a conductor or an insulator?

b. We want to use Gauss' law, $\int \mathbf{E} \cdot d\mathbf{A} = \frac{Q_{\text{enclosed}}}{\varepsilon_0}$, to find the electric field at a distance of 2m from the center of the sphere.

Draw a picture showing the appropriate imaginary Gaussian surface, draw the electric field $\mathbf{E}$ and the $d\mathbf{A}$ vector.

c. What is $Q_{\text{enclosed}}$ at 2m?

d. Evaluate the integral on the left hand side.

e. Find the electric field.

$$Q_{\text{enclosed}} = \frac{\text{Charge}}{\text{Volume}} \times (\text{Volume with charge})$$

$$= \frac{108\pi}{\frac{4}{3}\pi(3)^3} \times \frac{4}{3}\pi(2)^3$$

$$= 3.2\pi \text{ C}$$

$$\int \mathbf{E} \cdot d\mathbf{A} = \mathbf{E} \oint \mathbf{A} \cos 0^\circ \, d\mathbf{A} = \mathbf{E} \mathbf{A} (\text{sphere radius} 2\text{m})$$

$$= \mathbf{E} 4\pi (2)^2$$

$$= 16\pi \mathbf{E} \frac{N \cdot m^2}{C}$$

$$16\pi \mathbf{E} = \frac{Q_{\text{enclosed}}}{\varepsilon_0} = \frac{3.2\pi}{\varepsilon_0}$$

$$\mathbf{E} = \frac{2}{\varepsilon_0} \frac{N}{C}$$