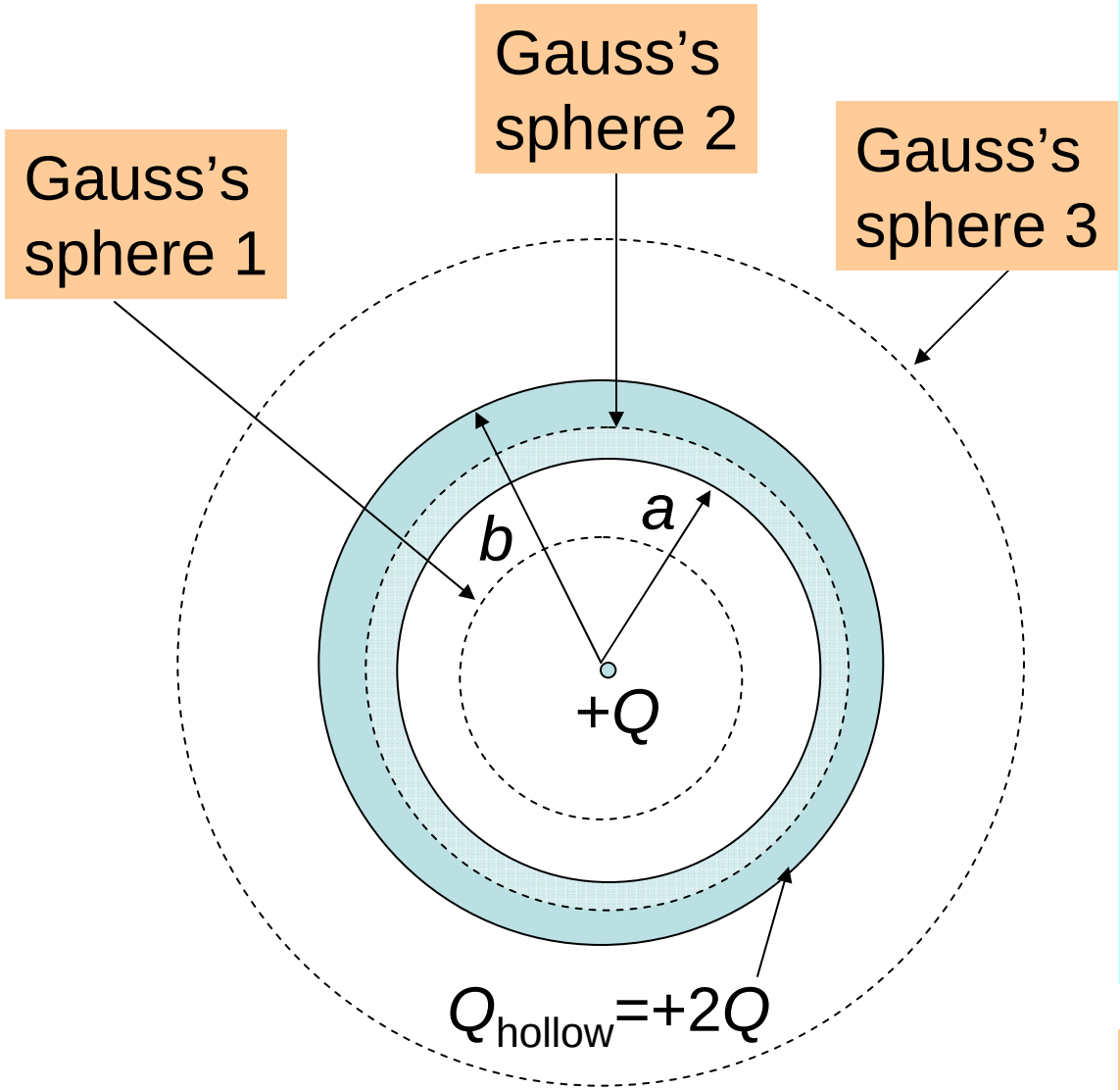
Review for Quiz 3, September 13, 2005



Problem 38, Chapter 27
A hollow metal sphere has inner radius *a* and outer radius *b*. The hollow sphere has charge +2*Q*. A point charge +*Q* sits at the center of the hollow sphere. Find:
a) $E(r)$: $r \le a$, $a < r < b$, and $r \ge b$
b) What is $Q_{hollow,\ inside}$ and $Q_{hollow,\ ext}$

Grading Criteria
- Gauss's law
- Equations for $E(r)$

Basic Principles

- The piece of metal can be charged, but its charge always resides on its surface. This happens since same charges repulse.

- Electric field can not exist inside the metal ($\boldsymbol{E}=0$) since otherwise the mobile charges would move (polarization effect) until they fully screen the electric field.

Read more in Section 27.6 Conductors in Electrostatic Equilibrium

Gauss's Laws for three different spheres

I Gaussian sphere: $\Phi_e = \frac{q_{enc}}{\varepsilon_0}$.

$\Phi_e = 4\pi r^2 \cdot E(r)$, q_{enc} – ? $q_{enc} = +Q$

$4\pi r^2 \cdot E(r) = +\frac{Q}{\varepsilon_0} \Rightarrow E(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$.

II Gaussian sphere:

$\Phi_e = \frac{q_{enc}}{\varepsilon_0}$, $\Phi_e \equiv 0$

This is since inside the metal E=0 .

$q_{enc} = +Q + Q_{hollow,\ inside} = 0$

$Q_{hollow,\ inside} = -Q$

$Q_{hollow,\ ext} - ?$

$Q_{hollow} = Q_{hollow,\ inside} + Q_{hollow,\ ext}$

$Q_{hollow,\ ext} = Q_{hollow} - Q_{hollow,\ inside} =$

$= +2Q + Q = 3Q$

III Gaussian sphere:

$\Phi_e = \frac{q_{enc}}{\varepsilon_0}$, $\Phi_e = 4\pi r^2 \cdot E(r)$

$q_{enc} = +3Q$

$4\pi r^2 \cdot E(r) = \frac{3Q}{\varepsilon_0} \Rightarrow E(r) = \frac{1}{4\pi\varepsilon_0} \frac{3Q}{r^2}$.