Physics 2220
Spring 2004
George A. Williams

SECOND MIDTERM

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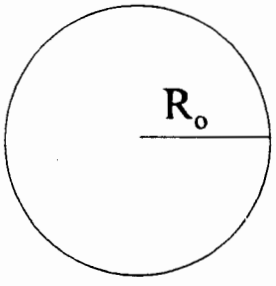
Name:_____

Discussion Instructor (circle): Billeter Blake Gillman Herring

Student ID #:_____

SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

Given a sphere of nonconductor with a charge density given by $\rho = \frac{\rho_0}{r^2}$ (for $r < R_o$).



(a) Find Q_T.
(b) Find E when $r < R_o$.
(c) Find E when $r > R_o$.
(d) Find the energy stored in the region $o < r < R_o$.
(e) If $\rho_o < 0$, what is the sign of $V(0) - V(R_o)$? Explain.

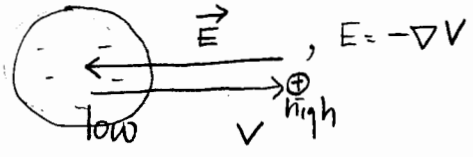
(a) $Q_T = \int \rho dV = \int_0^{R_o} \frac{\rho_0}{r^2} 4\pi r^2 dr = \underline{\underline{4\pi \rho_0 R_0}}$

(b) $\oint \vec{E} \cdot d\vec{A} = \frac{1}{\epsilon_0}\int \rho dV \Rightarrow E \cdot 4\pi r^2 = \frac{1}{\epsilon_0}\int_0^r \frac{\rho_0}{(r')^2} 4\pi (r')^2 dr' = \frac{1}{\epsilon_0} 4\pi \rho_0 r$

$\therefore E_{in} = \frac{1}{4\pi r^2} \cdot \frac{1}{\epsilon_0} 4\pi \rho_0 r = \underline{\underline{\frac{\rho_0}{\epsilon_0 r}}}$

(c) $\oint \vec{E} \cdot d\vec{A} = \frac{Q_T}{\epsilon_0} \Rightarrow E_{out} = \frac{kQ_T}{r^2} = \frac{k \cdot 4\pi \rho_0 R_0}{r^2} = \frac{4\pi \rho_0 R_0}{4\pi \epsilon_0 r^2} = \underline{\underline{\frac{\rho_0 R_0}{\epsilon_0 r^2}}}$

(d) $U = \int_0^{R_o} U_e dV = \int_0^{R_o} \frac{1}{2}\epsilon_0 E_{in}^2 \cdot 4\pi r^2 dr = \frac{\epsilon_0}{2}\int_0^{R_o} \left(\frac{\rho_0}{\epsilon_0 r}\right)^2 4\pi r^2 = \underline{\underline{\frac{2\pi \rho_0^2 R_0}{\epsilon_0}}}$

(e) 

, $E = -\nabla V$

$\therefore \underline{\underline{V(0) - V(R_o) < 0}}$, Negative.