Physics 4B
Fall 2017

$\boxed{\text{average} = 6.1 \quad \sigma = 2.1}$

Name: Answer Key

Lab (circle one): 8:00 am 11:15 am 2:45 pm

Quiz #3: Gauss' Law

Problem 1 (2 points)

Consider Gauss' law: $\oint \vec{E} \bullet d\vec{A} = \frac{q_{encl}}{\varepsilon_0}$.

Which of the following must be true?

a) $\vec{E}$ must be the electric field due to the enclosed charge. → not true, $\vec{E}$ is electric field at Gaussian surface; $\vec{E}$ can be from any charges

b) If $q_{encl} = 0$, then $\vec{E} = 0$ everywhere on the Gaussian surface. → not true, $\oint \vec{E} \cdot d\vec{A} = 0$

[✓ c)] If the Gaussian surface only encloses three charges that have charge $+q$, $+q$ and $-2q$, then the integral is zero.

d) If a charge is placed outside the Gaussian surface, then it cannot affect $\vec{E}$ at any point on the surface.

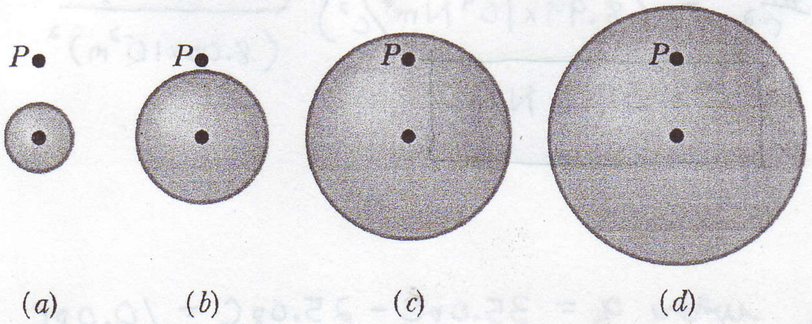
e) Two of the above.

↓ it will affect $\vec{E}$ but not $\oint \vec{E} \cdot d\vec{A}$ if q_{encl} doesn't change

$\boxed{C}$

Problem 2 (3 points)

The figure below shows four solid non-conducting spheres, each with charge Q uniformly distributed throughout its volume. **(a)** Rank the spheres according to their volume charge density, greatest first. The figure also shows a point P for each sphere, all at the same distance from the center of the sphere. **(b)** Rank the spheres according to the magnitude of the electric field they produce at point P, greatest first. **(c)** Now assume that the four spheres are conducting (and each has charge Q). Rank the spheres according to the magnitude of the electric field they produce at point P, greatest first.



$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ outside a sphere of uniform charge

$\Rightarrow E = \frac{qr}{4\pi\varepsilon_0 R^3}$ field inside uniformly charged sphere

a) $\boxed{a, b, c, d}$

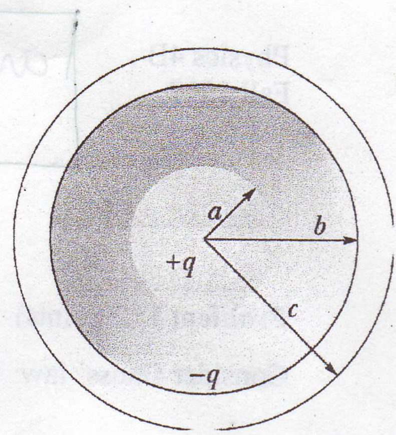
$\Rightarrow E = 0$ inside a conductor in electrostatic equilibrium

b) $\boxed{a = b, c, d}$

$\Rightarrow \rho = q/V = q/(4/3 \pi r^3)$

c) $\boxed{a = b, c = d \text{ (zero)}}$

Problem 3 (5 points)
In the figure to the right, a solid non-conducting sphere of radius a = 5.00 cm is concentric with a spherical conducting shell of inner radius b = 10.00 cm and outer radius c = 12.5 cm. The sphere has a net charge of +35.0 pC and the shell has a net charge of -25.0 pC.



What is the magnitude of the electric field at a radial distance of **(a)** r = 3.00 cm, **(b)** r = 8.00 cm, **(c)** r = 12.0 cm, and **(d)** r = 15.0 cm?

(e) What is the net charge in the inner and outer surfaces of the shell?

inside a uniformly charged sphere $\underline{E = \frac{1}{4\pi\varepsilon_0}\frac{qr}{R^3}}$

outside of sphere or outside of shell $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ where q is total charge

inside of spherical shell $\underline{E = 0}$

* note all of these can be derived from Gauss' Law but you did not need to derive above equations for quiz

a) $r<a \quad E = \frac{1}{4\pi\varepsilon_0}\frac{qr}{R^3} = (8.99\times10^9\,\mathrm{Nm^2/c^2})\frac{(35\times10^{-12}\,\mathrm{C})(3.00\times10^{-2}\,\mathrm{m})}{(5.00\times10^{-2}\,\mathrm{m})^3}$

$\boxed{E = 75.5\,\mathrm{N/c}}$

b) $a<r<b \quad E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = (8.99\times10^9\,\mathrm{Nm^2/c^2})\frac{(35\times10^{-12}\,\mathrm{C})}{(8.00\times10^{-2}\,\mathrm{m})^2}$

$\boxed{E = 49.2\,\mathrm{N/c}}$

c) $b<r<c \quad \boxed{E = 0}$

d) $r>c \quad E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ where $q = 35.0\,\mathrm{pC} - 25.0\,\mathrm{pC} = 10.0\,\mathrm{pC}$

$= (8.99\times10^9\,\mathrm{Nm^2/c^2})\frac{(10.0\times10^{-12}\,\mathrm{C})}{(15\times10^{-2}\,\mathrm{m})^2} = \boxed{4.00\,\mathrm{N/c}}$

e) inner surface $\boxed{q = -35.0\,\mathrm{pC}}$

outer surface $\boxed{q = +10.0\,\mathrm{pC}}$