AP Physics Fall 2013/Spring 2014
Test 16 – Electric Fields & Electric Potential

Name: Key

Multiple Choice (Problems 1- 8)	_____	32 pts
Problem 9	_____	8 pts
Problem 10	_____	10 pts
Problem 11	_____	10 pts
Problem 12	_____	10 pts
Problem 13	_____	8 pts
Problem 14	_____	12 pts
Problem 15	_____	10 pts
Bonus	_____	18 pts
Total	_____	

Constants
universal gas constant = 8.314 J mol^{-1} K^{-1}
Boltzmann constant = 1.38 x 10^{-23} J K^{-1}
Stefan-Boltzman = 5.67 x 10^{-8} W m^{-2} K^{-4}
Avogadro's number = 6.022 x 10^{23} mol^{-1}
Charge on an electron = 1.6x10^{-19} C
Mass of an electron = 9.11 x 10^{-31} kg
Permittivity of free space = 8.85 x 10^{-12} $C^2/(N*m^2)$

Name: _____

1. The plates of a parallel plate capacitor are maintained at constant voltage by a battery as they are pulled apart. During the process, the amount of charge on the plates must

$C = \frac{\epsilon_0 A}{d}$ C goes down as d goes up

$\downarrow Q = \downarrow C V$

A. remain constant.

B. decrease.

C. increase.

D. either increase or decrease. There is no way to tell with the information given.

2. A surface on which all points are at the same potential is referred to as

A. as a constant electric field surface.

B. an equivoltage surface.

C. a constant electric force surface.

D. an equipotential surface.

3. The energy acquired by a particle carrying a charge equal to that of a proton as a result of moving through a potential difference of one volt is referred to as

A. a farad.

B. an electron-volt.

C. a coulomb.

D. a joule.

Name: _____

4. Several electrons are placed on a hollow conducting sphere. They

A. become uniformly distributed on the sphere's outer surface.

B. clump together on the sphere's outer surface.

C. clump together on the sphere's inner surface.

D. become uniformly distributed on the sphere's inner surface.

5. A dielectric material such as paper is placed between the plates of a capacitor. What happens to the capacitance?

$C = K C_{Air} > C_{air}$

A. becomes smaller.

B. no change.

C. becomes larger.

D. becomes infinite.

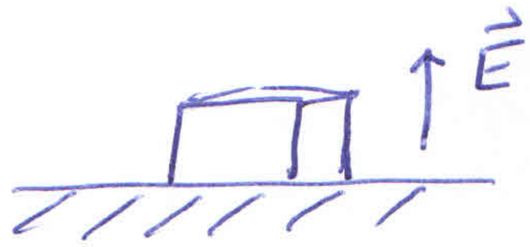
6. A charge of 60 μC is placed on a 15 μF capacitor. How much energy is stored in the capacitor?

A. 4.0 J **B.** 120 J **C.** 120 μJ **D.** 240 μJ

$$U = \frac{1}{2} C V^2 = \frac{Q^2}{2C} = \frac{(60\mu C)^2}{2(15\mu F)} = 120\mu J$$

Name: _____

7. A cubic block of aluminum rests on a wooden table in a region where a uniform electric field is directed straight upward. What can be said concerning the charge on the block's top surface?



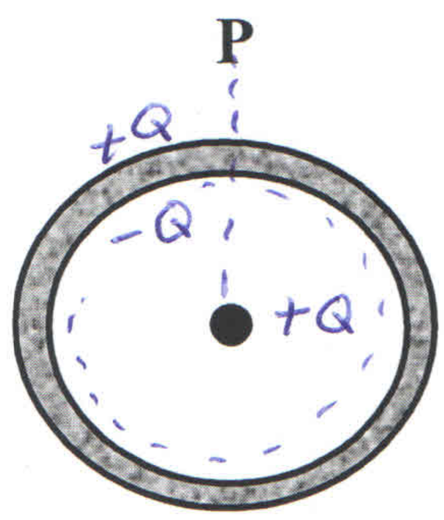
A. The top surface is charged positively.

B. The top surface is neutral.

C. The top surface is charged negatively

D. The top surface's charge cannot be determined without further information. Need to know if the block is charged

8. An uncharged metal sphere is placed around a positive point charge as shown below.



$E = \frac{kQ}{r^2}$

As compared to the case without the hollow sphere, the electric field at point P directly above the hollow sphere has

A. diminished somewhat.

B. diminished to zero.

C. increased somewhat.

D. not changed.

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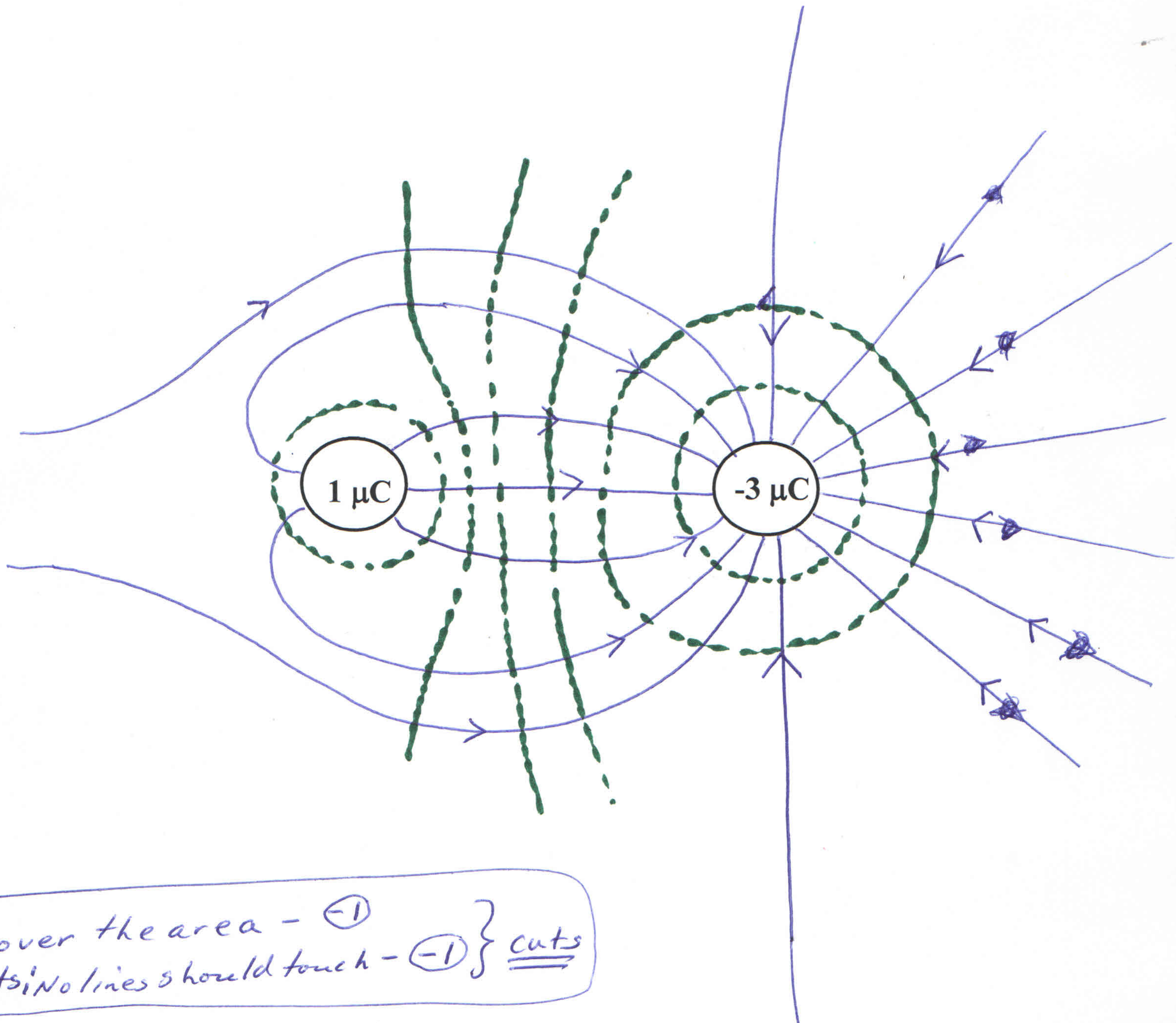
8 pts **9.** Draw the electric field lines and equipotential surfaces for the following charge distribution.



Cover the area - (-1)
cuts; No lines should touch - (-1) } cuts

(+2) - Lines go into "-" charge

(+2) - Lines start at ∞ or "+" charge

(+2) - 3x as many lines to negative as positive charge

(+2) - Equipotential surfaces

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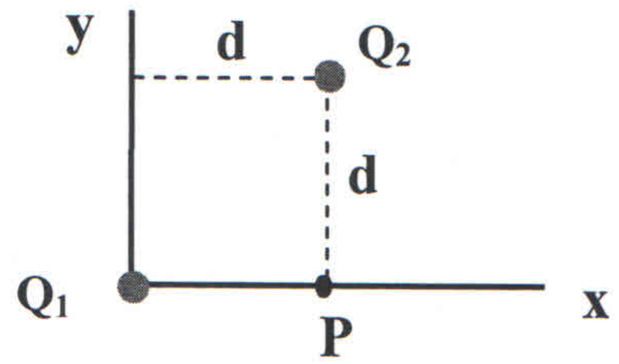
10 pts **10.** Two point charges ($Q_1 = -3.00\ \mu C$ and $Q_2 = 4.00\ \mu C$ are located at the vertices of a square with sides of length $d = 40$ cm.



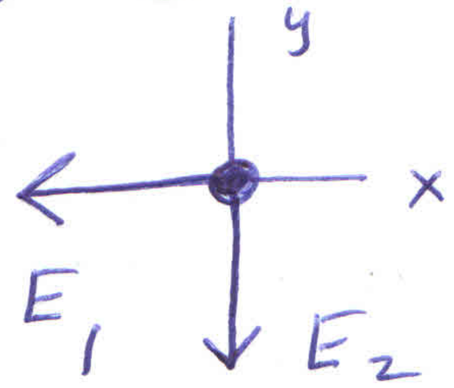
Find the electric field at point P on the x-axis.

$$E_1 = \frac{k|Q_1|}{d^2} = \frac{(9\times10^9\ Nm^2/C^2)(3\times10^{-6}\ C)}{(0.4m)^2} \cong 1.688\times10^5\ N/C$$

(+2) (+1) (+1)

$$E_2 = \frac{k|Q_2|}{d^2} = \frac{(9\times10^9\ Nm^2/C^2)(4\times10^{-6}\ C)}{(0.4m)^2} \cong 2.25\times10^5\ N/C$$

(+2) (+1) (+1)



$$\vec{E} = -E_1\hat{i} - E_2\hat{j}$$

$$\vec{E} \cong -1.69\times10^5\ N/C\ \hat{i} - 2.25\times10^5\ N/C\ \hat{j}$$

(+1) (+1)

or

$$\vec{E} \cong 2.81\times10^5\ N/C \text{ @ } 233^\circ$$

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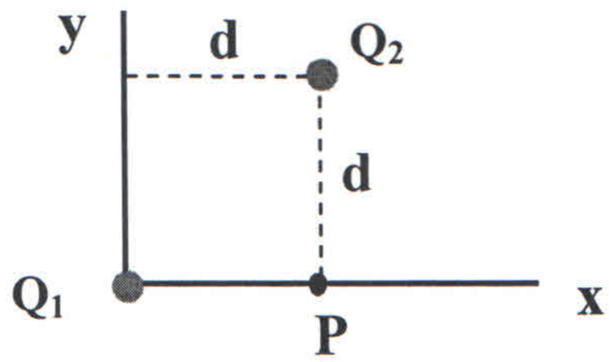
10 pts **11.** Two point charges ($Q_1 = -3.00\ \mu C$ and $Q_2 = 4.00\ \mu C$ are located at the vertices of a square with sides of length $d = 40$ cm.



Find electric potential at point P on the x-axis?

$$V_1 = \frac{kQ_1}{d} = \frac{\left(9\times10^9 \frac{Nm^2}{C^2}\right)(-3\times10^{-6}C)}{(0.4m)} \cong \boxed{-6.75\times10^4 V}$$

(+1) (+1) (+1) (+1) (+1)

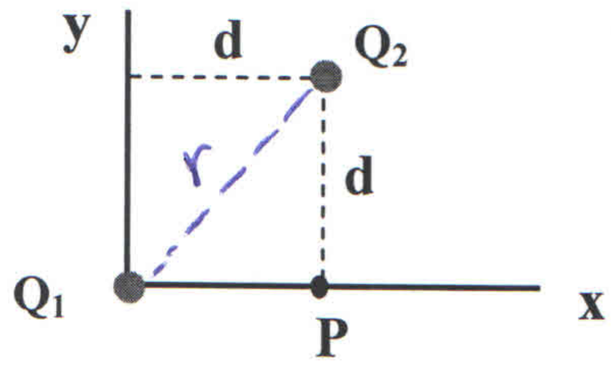
$$V_2 = \frac{kQ_2}{d} = \frac{(9\times10^9 Nm^2/C^2)(4\times10^{-6}C)}{(0.4m)} \cong \boxed{9.00\times10^4 V}$$

(+1) (+1) (+1) (+1) (+1)

$$V = V_1 + V_2 = \boxed{2.25\times10^4 \text{ Volts}} \text{ or } \boxed{22.5\,kV}$$

(+1) (+1)

10 pts **12.** Two point charges ($Q_1 = -3.00\ \mu C$ and $Q_2 = 4.00\ \mu C$ are located at the vertices of a square with sides of length $d = 40$ cm.



How much work was done against the electric force in assembling this charge distribution?

(+4) $U = \dfrac{kQ_1Q_2}{r}$

(+2) $r = \sqrt{d^2+d^2} = \sqrt{(0.4m)^2+(0.4m)^2}$

$r \cong 0.5657m$ (+1)

$U \cong \dfrac{(9\times10^9 Nm^2/C^2)(-3\times10^{-6}C)(4\times10^{-6}C)}{0.5657m}$

$U \cong \boxed{-0.191\,J}$ (+2) # (+1) units

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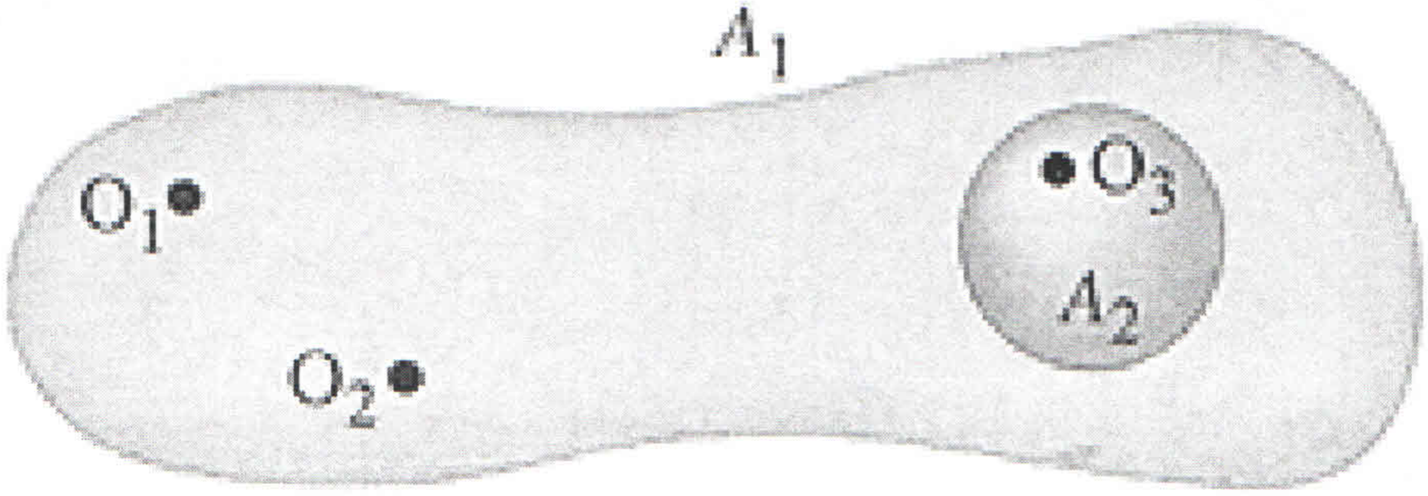
8 pts **13.** In the figure below, three objects O_1, O_2, and O_3 have the charges -3.5 μA, 2.5 μC, and 4 μC respectively.



What is the electric flux through the blue sphere A_2 of radius 10 cm?

$$\Phi_{closed} = \frac{Q_{enclosed}}{\epsilon_0}$$ (+3)

$$Q_{enclosed} = q_3 = 4\mu C$$ (+2)

$$\Phi_{closed} = \frac{4\times10^{-6} C}{8.85\times10^{-12} C^2/Nm^2}$$

$$\Phi_{closed} \cong \boxed{4.52\times10^{5} \frac{Nm^2}{C}}$$ — # (+2) — units (+1)

Name: _____

12 pts **14.** A parallel plate capacitor has plates with area $1.5 \times 10^{-4}\ m^2$ separated by 1.0 mm.

6 pts **A.** What is the capacitor's capacitance?

$$C = \frac{\epsilon_0 A}{d}$$ (+3)

$$C = \frac{(8.85 \times 10^{-12}\ C^2/N m^2)(1.5 \times 10^{-4}\ m^2)}{1 \times 10^{-3}\ m}$$ (+1)

$$C \cong \boxed{1.33 \times 10^{-12}\ F} \cong \boxed{1.33\ pF}$$ (+1) # (+1) units

6 pts **B.** When a 10 volt battery is connected to the capacitor what is the magnitude of the electric field between the capacitor's plates?

$$V = E d$$ (+2)

$$E = V/d$$ (+1)

3 -

$$E = \frac{10\ V}{1 \times 10^{-3}\ m} = \boxed{1.0 \times 10^4\ V/m} = \boxed{10\ kV/m}$$

1 (#+2) 1 (+1 units)

Name: _____

10 pt **15.** An electron is placed in a uniform electric field of 2500 N/C in the positive x-direction.

6 pts **A.** What is the magnitude of the force upon the electron?

$F = qE$ (+3)

$F = (1.6 \times 10^{-19} C)(2.5 \times 10^{3} N/C)$ (+1)

$F \cong \boxed{4.0 \times 10^{-16} N}$ – (+1) # – (+1) units

4 pts **B.** What is the electron's acceleration?

$a = \frac{F}{m}$ (+1)

$a = \frac{4.0 \times 10^{-16} N}{9.11 \times 10^{-31} kg}$ (+1)

$a \cong \boxed{4.39 \times 10^{14} m/s^2}$ – (+1) # – (+1) units

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BONUS PROBLEMS

8 pts **1.** An alpha particle (charge +2e, mass 6.64×10^{-27} kg) moves head-on at a fixed gold nucleus (charge +79e). If the distance of closest approach is 2×10^{-10} m (i.e. location where alpha temporarily comes to rest), what was the initial speed of the alpha particle?

$W_{nc} = \Delta K + \Delta U$ ($W_{nc} = 0$)

But electric force is conservative

(+2) $\Delta U = -\Delta K$

$U_f - U_i = -K_f + K_i$

(+1) $\frac{k(2e)(Ze)}{r_f} - \frac{k(2e)(Ze)}{\infty} = -\frac{1}{2}m v_f^2 + \frac{1}{2}m v_i^2$ (+1)

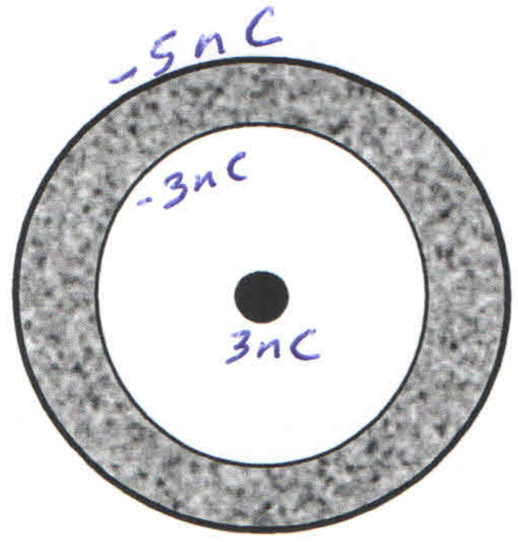
(+1) $v_i = \sqrt{\frac{ke^2 4Z}{r_f m}}$

$v_i = \sqrt{\frac{(9\times10^9 Nm^2/C^2)(1.6\times10^{-19}C)^2(4)(79)}{(2\times10^{-10}m)(6.64\times10^{-27}kg)}}$

$v_i \cong \boxed{2.34\times10^5 m/s}$ – # (+2) – units (+1)

Name: _____

10 pts **2.** A net charge of -8.0 nC is placed on a metal hollow sphere of inner radius 40 cm and outer radius of 60 cm. A +3 .0 nC point charge placed at the center of the sphere (origin) as shown below:



4 pts A. Tell the location(s) and amount(s) of the charge on the sphere.

(+2) $-3nC$ on inside surface of the sphere @ r=0.4m

(+2) $-5nC$ on outside surface of the sphere @ r=0.6m

2 pts B. What is the magnitude of the electric field at a distance of 20 cm from the center of the hollow sphere?

$$E = \frac{k|Q|}{r^2} = \frac{(9\times10^9 Nm^2/C^2)(3\times10^{-9}C)}{(0.2m)^2}$$

$E = \boxed{675\ N/C}$ (+1) # (+1) units

2 pts C. What is the magnitude of the electric field at a distance of 50 cm from the center of the hollow sphere?

$E = 0 \frac{N}{C}$

2 pts D. What is the magnitude of the electric field at a distance of 70 cm from the center of the hollow sphere?

$E = \frac{k|Q|}{r^2} = \frac{(9 \times 10^9 Nm^2/C^2)(5 \times 10^{-9} C)}{(0.7m)^2}$

$E \cong 91.8 \; N/C$ — (+1) #, — (+1) units