

1 Part 1: Conceptual Problems (4 points each)

Circle the letter of your answer for each problem.

- The fundamental force underlying all chemical reactions is...
 - gravitational.
 - nuclear.
 - centripetal.
 - electrical.
 - none of these.
- If an atom has become a positive ion, it has
 - gained a proton or protons.
 - gained an electron or electrons.
 - lost a proton or protons.
 - lost an electron or electrons.
- The unit of electric charge, the coulomb, is the magnitude of the charge on
 - one electron.
 - 1.6×10^{-19} electrons.
 - 6.25×10^{18} electrons.
$$1 e = 1.6 \times 10^{-19} C$$

$$1 C = 6.25 \times 10^{18} e$$
- The electrical force between charges is strongest when the charges are
 - close together.
 - far apart.
 - the electric force is constant everywhere.
- Rub electrons *from* a glass rod with a piece of silk and *the glass rod becomes*
 - negatively charged.
 - positively charge.
- Hold a negatively-charged balloon near a neutral wall and the balloon sticks as the wall becomes polarized. This means
 - The wall becomes positively charged, thus attracting the negative balloon.
 - Negative charges in the wall shift away from the surface, so the balloon is more attracted to the positive charges that are closer.
 - Because the balloon is negative, it can only be affected by the positive charges in the wall.
 - Because the wall is neutral, only the gravitational attraction matters, and the balloon sticks.
- Electric potential, measured in volts, is the ratio of electric energy to amount of electric
 - current.
 - resistance.
 - charge.
 - voltage.
 - none of these.
$$V = \frac{EPE}{Q} = \frac{\text{Electric Energy}}{\text{Charge}}$$
- When the distance between two charges is *doubled*, the electrical force between the charges
 - is increased by a factor of 4.
 - doubles.
 - is reduced by 1/2.
 - is reduced by 1/4.
 - none of these.
$$F = k \frac{q_1 q_2}{R^2}$$

Part 1 Continued.

Name: Solutions

9. To say that electric charge is conserved means that *no case* has ever been found where
- (a) the total charge on an object has changed.
 - (b) there is a net negative charge in a lab.
 - (c) the total amount of charge on an object has increased.
 - (d) net charge has been created or destroyed.
 - (e) none of these.

Charge only moves.

10. The direction of an electric field is the direction of the force that it would exert on
- (a) a neutron.
 - (b) an electron.
 - (c) an atom.
 - (d) a proton.
 - (e) a molecule.

11. If you use 10 J of work to push a +2 coulomb charge into an electric field, its voltage with respect to its starting position is

$$V = \frac{\Delta E_{PE}}{Q} = \frac{10 \text{ J}}{2 \text{ C}} = 5 \text{ V}$$

- (a) less than 10 V.
- (b) 10 V.
- (c) more than 10 V.

12. The electric field inside an uncharged solid metal ball is zero. If the ball is given a negative charge, the electric field inside the ball will be

E = 0 inside conductor

- (a) less than zero.
- (b) zero.
- (c) greater than zero.

13. A proton and an electron are placed in the same electric field. Which undergoes the greater acceleration?

$$F = ma$$

*F is the same mag.
m of electron is smaller.*

- (a) electron
- (b) proton
- (c) both accelerate equally
- (d) neither accelerates

14. A dielectric capacitor has a capacitance of 16 μF and a dielectric with $\kappa_i = 5$. If the dielectric is replaced by one with $\kappa_f = 20$, what will the new capacitance be?

$$\begin{array}{l} K=5 \quad C=16 \mu\text{F} \\ N_0 K \quad C_0=16/5 \mu\text{F} \end{array}$$

$$K=20 \quad C=20 \cdot 16/5 = 64 \mu\text{F}$$

- (a) 4 μF
- (b) 16 μF
- (c) 32 μF
- (d) 64 μF

15. All objects seek out regions of low potential energy. The electric potential that an electron prefers would therefore be

negative charge

- (a) high electric potential.
- (b) zero electric potential.
- (c) low electric potential.

16. A capacitor with a capacitance of C has a voltage of V . If the voltage across the capacitor is doubled, the capacitance C

$$q = CV$$

only q & V change.

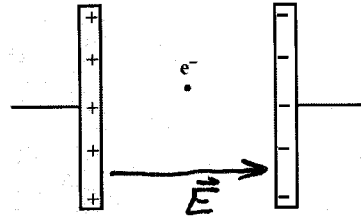
- (a) doubles.
- (b) is decreased by 1/2.
- (c) stays the same.
- (d) can't be determined with the information given.

2 Parallel Plate Capacitor

Name: Solutions

Points

(18 Points) An electron is released from rest in the middle of a parallel plate capacitor. The charge per unit area on each plate of the capacitor is $\sigma = 1.8 \times 10^{-7} \frac{C}{m^2}$ and the plates are separated by a distance of $1.5 \times 10^{-2} m$.



4

A. Toward which plate (positive or negative) will the electron move?

B. What is the electric field inside this capacitor? (Include the direction.)

3

$$E = \frac{\sigma}{\epsilon_0} = \frac{1.8 \times 10^{-7} \frac{C}{m^2}}{8.85 \times 10^{-12} \frac{C^2}{Nm^2}} = 2.03 \times 10^4 \frac{N}{C}$$

2 To the right.

C. What is the force on the electron? (Include the direction.)

3

2(dir)

$$\begin{aligned} \vec{F} &= q\vec{E} \\ &= (-1.6 \times 10^{-19} C)(2.03 \times 10^4 \frac{N}{C} \text{ to the right}) \\ &= 3.25 \times 10^{-15} N \text{ to the left} \end{aligned}$$

D. What is the potential difference of the capacitor?

4

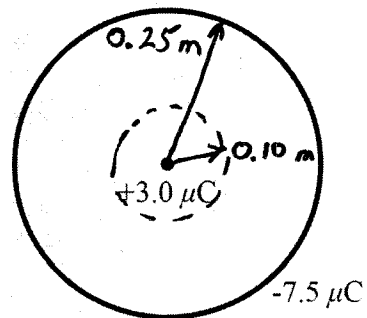
$$\begin{aligned} V &= Ed = (2.03 \times 10^4 \frac{N}{C})(1.5 \times 10^{-2} m) \\ &= 305 V \end{aligned} \quad L = \frac{V}{m}$$

3 Gauss's Law

Name: Solutions

(18 Points) A thin metal shell with a radius of $R_S = 0.25\text{ m}$ has a charge of $q_2 = -7.5\text{ }\mu\text{C}$. At the center of the shell is a point charge $q_1 = 3\text{ }\mu\text{C}$.

A. Use Gauss's Law (draw your Gaussian surface as a dashed line on the figure to the right) to find the flux Φ leaving a sphere of radius $R_1 = 0.10\text{ m}$. Then, find the electric field E at the distance $R_1 = 0.10\text{ m}$ from the center.



Points

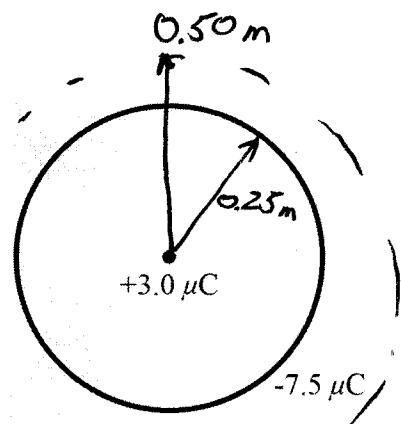
3 $Q_{enc} = +3.0\text{ }\mu\text{C}$
 3 $\Phi = \frac{3.39 \times 10^5\text{ Nm}^2}{\text{C}}$
 3 $E = 2.70 \times 10^6\text{ N/C}$ Outward

$$\Phi = \frac{Q_{enc}}{\epsilon_0} = \frac{3.0 \times 10^{-6}\text{ C}}{8.85 \times 10^{-12}\frac{\text{C}^2}{\text{Nm}^2}} = 3.39 \times 10^5\frac{\text{Nm}^2}{\text{C}}$$

$$EA = \Phi \quad \therefore E = \frac{\Phi}{A} = \frac{3.39 \times 10^5\frac{\text{Nm}^2}{\text{C}}}{0.126\text{ m}^2} = 2.70 \times 10^6\text{ N/C}$$

$$A = 4\pi R^2 = 4\pi (0.10)^2 = 0.126\text{ m}^2$$

B. Use Gauss's Law (draw your Gaussian surface as a dashed line on the figure to the right) to find the flux Φ leaving a sphere of radius $R_2 = 0.50\text{ m}$. Then, find the electric field E at the distance $R_2 = 0.50\text{ m}$ from the center.



3 $Q_{enc} = -4.5\text{ }\mu\text{C}$ b/c both charges
 3 are enclosed.
 3 $\Phi = \frac{-5.08 \times 10^5\text{ Nm}^2}{\text{C}}$
 $E = -1.62 \times 10^5\text{ N/C}$ (neg means inward)

$$\Phi = \frac{Q_{enc}}{\epsilon_0} = \frac{-4.5 \times 10^{-6}\text{ C}}{8.85 \times 10^{-12}\frac{\text{C}^2}{\text{Nm}^2}} = -5.08 \times 10^5\frac{\text{Nm}^2}{\text{C}}$$

$$A = 4\pi R^2 = 4\pi (0.50)^2 = 3.14\text{ m}^2$$

$$EA = \Phi \quad \therefore E = \frac{\Phi}{A} = \frac{-5.08 \times 10^5\frac{\text{Nm}^2}{\text{C}}}{3.14\text{ m}^2} = -1.62 \times 10^5\frac{\text{N}}{\text{C}}$$