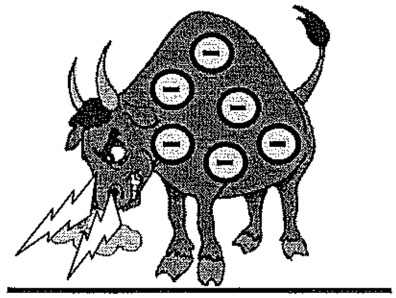
— Solutions —

Name____________________________

Ch 23. Electric Charge - HW



Charge!.......Charge!

Lesson 1. Discrete Charge

1. Explain charge as a property of matter. How is charge quantified?

Charge is an observable property of macroscopic matter when there is an imbalence of electrons and protons and we observe the electrostatic force $F = k\frac{q_1 q_2}{r^2}$.

Charge is quantified based on a unit electron or proton w/ charge value $\pm 1.609 \times 10^{-19}$ C.

2. What does conservation of charge of mean?

Charge can not be created or destroyed. When electrons are transferred there is a net + or − charge value based on losing or recieving the electrons

4 • A charge equal to the charge of Avogadro's number of protons ($N_A = 6.02 \times 10^{23}$) is called a *faraday*. Calculate the number of coulombs in a faraday.

$$6.02 \times 10^{23} \text{ protons} \cdot \frac{1.6 \times 10^{-19} \text{ C}}{1 \text{ proton}} = \boxed{96{,}320 \text{ C}}$$

5 • How many coulombs of positive charge are there in 1 kg of carbon? Twelve grams of carbon contain Avogadro's number of atoms, with each atom having six protons and six electrons.

$N_A = 6.02 \times 10^{23}$
$M_c = 44.01 \text{ g/mol}$
$Z_c = 6$

$$1 \text{ kg C} \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{1 \text{ mol}}{44.01 \text{ g}} \cdot \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}} \cdot \frac{6 \text{ protons}}{1 \text{ atom}} =$$

$$8.19 \times 10^{25} \text{ protons}$$

$$8.19 \times 10^{25} \text{ protons} \cdot \frac{1.6 \times 10^{-19} \text{ C}}{1 \text{ proton}} = \boxed{1.31 \times 10^{7} \text{ C}}$$

Lesson 2. Conductors and Insulators

3. What are the characteristics of a conductor?

The conduction band energy levels are occupied and electrostatically shielded from the + nucleus allowing for "drifting" of electrons w/ in the lattice structure of the metal.

| Conduction |
| Valence |

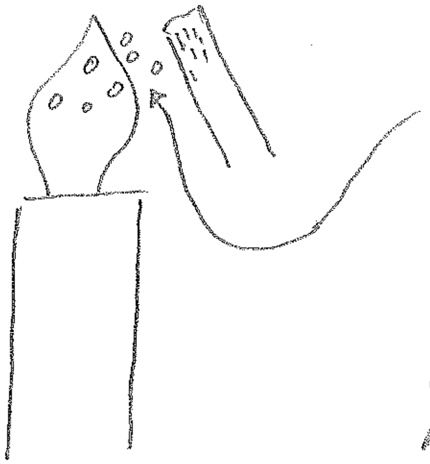
4. What are characteristics of an insulator?

The conduction band energy levels are not occupied or accessible to the valence electrons

| Conduction |

| Valance |

5. A charged insulator can be discharged by passing it just above a flame. Explain why?



The air molecules in and near the flame become energetic due to heat energy (IR photons) The electrons in these molecules become excited into higher energy levels which are then accessible to give up or recieve electrons from the insulator thereby neutralizing it.

6. If you rub a coin briskly between your fingers, it will not become charged. Why not?

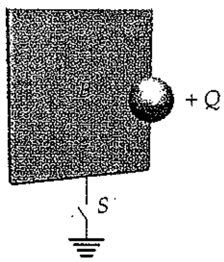
Since a coin is a metal, a good conductor, the electrons will continuously flow through it. Your hand represents a ground, a continuous source of electrons. No net charge can build on the metal this way because the coin is continuously grounded.

Lesson 3. Charging by Induction

7 •• A metal rectangle B is connected to ground through a switch S that is initially closed (Figure 22-28). While the charge $+Q$ is near B, switch S is opened. The charge $+Q$ is then removed. Afterward, what is the charge state of the metal rectangle B?

(*a*) It is positively charged.
(*b*) It is uncharged.
(*c*) It is negatively charged.
(*d*) It may be any of the above depending on the charge on B before the charge $+Q$ was placed nearby.

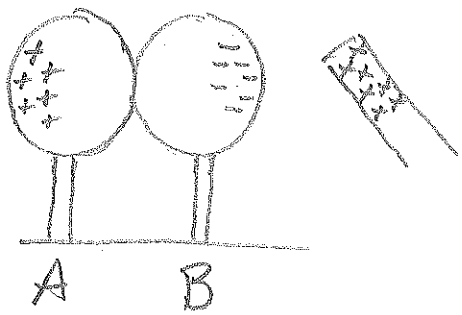
Figure 22-28 Problem 7



The +Q pulls electrons up from ground which are then trapped when the switch is then opened, so the plate B will be charged −

9 •• Two uncharged conducting spheres with their conducting surfaces in contact are supported on a large wooden table by insulated stands. A positively charged rod is brought up close to the surface of one of the spheres on the side opposite its point of contact with the other sphere. (*a*) Describe the induced charges on the two conducting spheres, and sketch the charge distributions on them. (*b*) The two spheres are separated far apart and the charged rod is removed. Sketch the charge distributions on the separated spheres.

(a.)

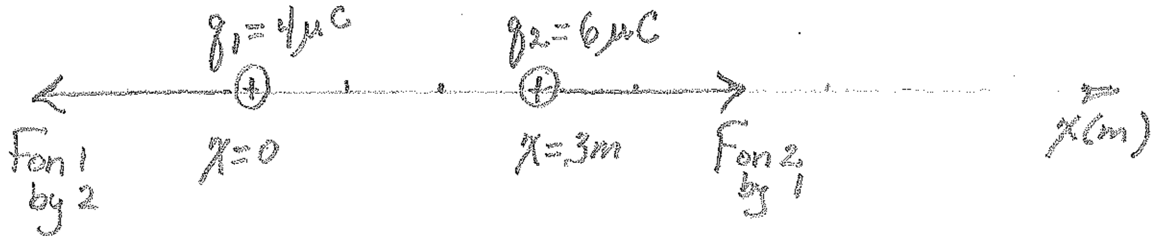


The spheres polarize. The electrons are pulled to the + charged rod making B − and leaving a net + charge on A.

(b.) When A and B are separated the electrons are trapped on B making it − and leaving A +.

Lesson 4. Coulomb's Law

11 • A charge $q_1 = 4.0\ \mu C$ is at the origin, and a charge $q_2 = 6.0\ \mu C$ is on the x axis at $x = 3.0$ m. (*a*) Find the force on charge q_2. (*b*) Find the force on q_1. (*c*) How would your answers for parts (*a*) and (*b*) differ if q_2 were $-6.0\ \mu C$?



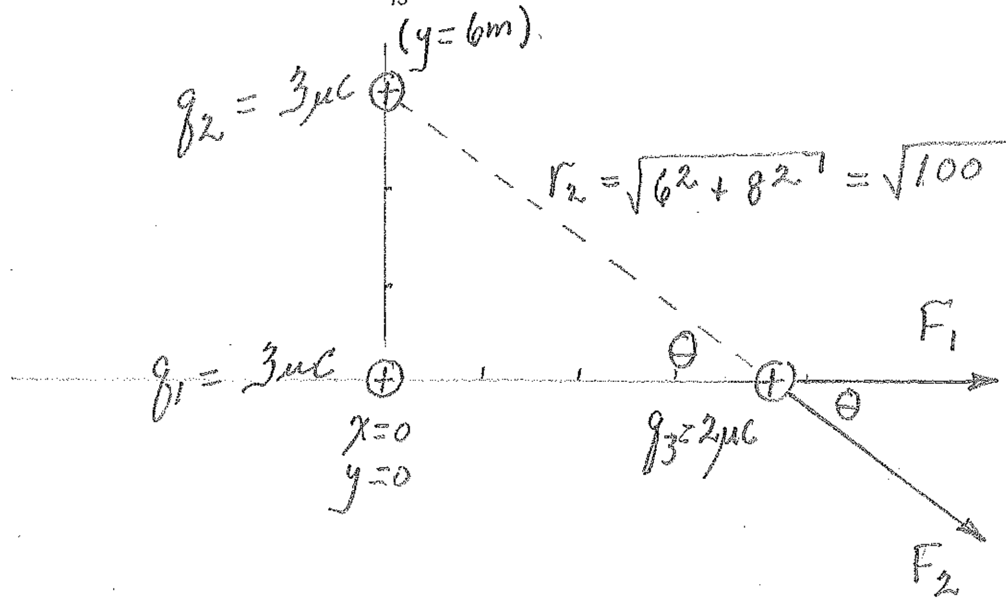
a.) $F_{\text{on 2 by 1}} = \frac{k q_1 q_2}{r^2} = \frac{9\times10^9 (4\times10^{-6})(6\times10^{-6})}{3^2}$

$= \boxed{.024\ N\ (+\hat{x})}$

b.) $F_{\text{on 1 by 2}} = \boxed{.024\ N\ (-\hat{x})}$ Newton's 3rd Law A-R Pair

c.) The magnitude would stay the same but the directions would be reversed since + and − attract.

13 •• Two equal charges of 3.0 μC are on the y axis, one at the origin and the other at $y = 6$ m. A third charge $q_3 = 2\ \mu$C is on the x axis at $x = 8$ m. Find the force on q_3.



$r_2 = \sqrt{6^2 + 8^2} = \sqrt{100} = 10$

$\theta = \tan^{-1}\left(\frac{6}{8}\right) = 36.9°$

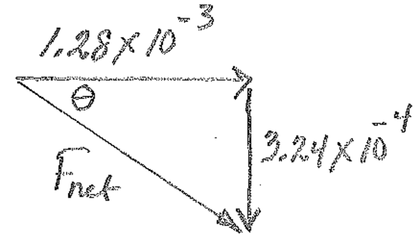
$$F_2 = \frac{k\, q_2 q_3}{r_2^2} = \frac{9\times10^9 (3\times10^{-6})(2\times10^{-6})}{100} = 5.4\times10^{-4}\ N$$

$$F_{2x} = 5.4\times10^{-4} \cos(36.9°) = 4.32\times10^{-4}\ N\ (+\hat{x})$$

$$F_{2y} = 5.4\times10^{-4} \sin(36.9°) = 3.24\times10^{-4}\ N\ (-\hat{y})$$

$$F_1 = \frac{9\times10^9 (3\times10^{-6})(2\times10^{-6})}{8^2} = 8.44\times10^{-4}\ N\ (+\hat{x})$$

$$\boxed{F_{Net} = 1.28\times10^{-3}\,\hat{x} - 3.24\times10^{-4}\,\hat{y}}$$



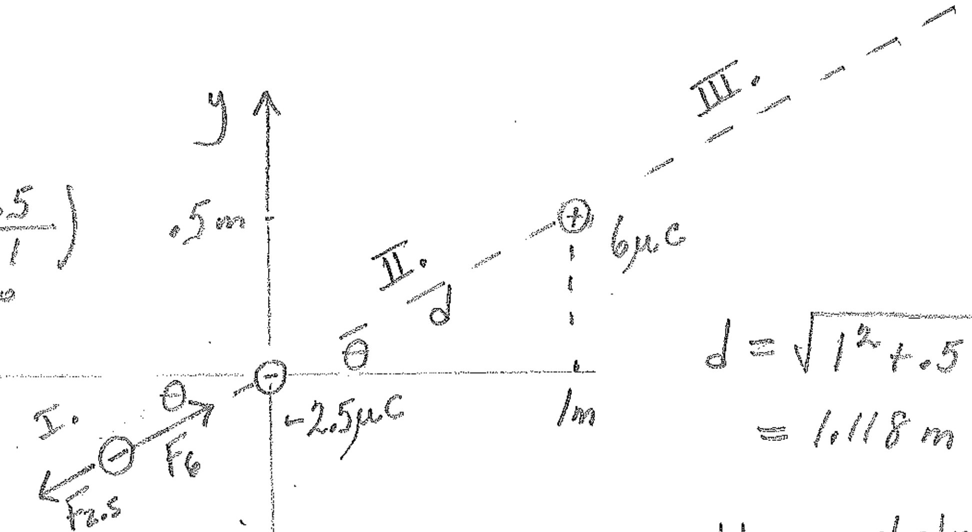
$F_{net} = 1.32\ N$, $\theta = -14.2°$

$$\theta = \tan^{-1}\left(\frac{3.24\times10^{-4}}{1.28\times10^{-3}}\right) = 14.2°$$

16 •• A point charge of $-2.5\ \mu C$ is located at the origin. A second point charge of $6\ \mu C$ is at $x = 1$ m, $y = 0.5$ m. Find the x and y coordinates of the position at which an electron would be in equilibrium.

$q_e = -1.6\times10^{-19}$ C

$\theta = \tan^{-1}\left(\frac{.5}{1}\right) = 26.6°$



$d = \sqrt{1^2 + .5^2} = 1.118$ m

III. Can't work since + 6μC pull would overwhelm the −2μC push

II. " " " both would push the electron toward the 6μC

I. will work. (let r be the distance from −2.5 μC into region I. along the dashed line)

$$F_{2.5} \text{ push} = \frac{9\times10^9(2.5\times10^{-6})(1.6\times10^{-19})}{r^2} = \frac{3.6\times10^{-15}}{r^2}$$

$$F_6 \text{ pull} = \frac{9\times10^9(6\times10^{-6})(1.6\times10^{-19})}{(1.118+r)^2} = \frac{8.64\times10^{-15}}{(1.118+r)^2}$$

$$\frac{3.6\times10^{-15}}{r^2} = \frac{8.64\times10^{-15}}{(r^2 + 2.236r + 1.25)}$$

$$3.6\times10^{-15}r^2 + 8.05\times10^{-15}r + 5.4\times10^{-15} = 8.64\times10^{-15}r^2$$

$$5.04\times10^{-15}r^2 - 8.05\times10^{-15}r - 5.4\times10^{-15} = 0$$

r = 2.1 m or ~~−.509 m~~

$x = -2.1\cos(26.6°) =$ **−1.88 m**

$y = -2.1\sin(26.6°) =$ **−.94 m**

AP PHYSICS 2	CH 23. - *ELECTRIC CHARGE*

Name ____________________ Date ______________

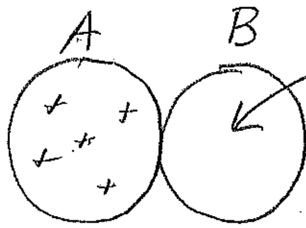
Period ______

Practice Questions

So you think you know it all. You're ready for the quiz, and don't need to study. Ok hot shot, show me what you know!

_____ 1. A positively charged metal sphere A is brought into contact with an uncharged metal sphere B. As a result:

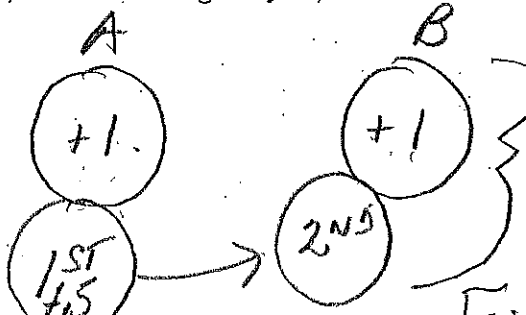
A. both spheres are positively charged
B. A is positively charged and B is neutral
C. A is positively charged and B is negatively charged
D. A is neutral and B is positively charged
E. A is neutral and B is negatively charged



B becomes +
Conservation of charge leaves A still + but smaller

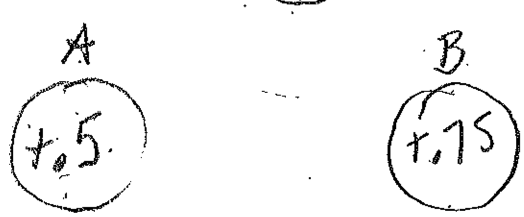
_____ 2. Two identical conducting spheres, A and B, carry equal charge. They are separated by a distance much larger than their diameters. A third identical conducting sphere, C, is uncharged. Sphere C is first touched to A, then to B, and finally removed. As a result, the electrostatic force between A and B, which was originally F, becomes:

A. $F/2$
B. $F/4$
C. $3F/8$
D. $F/16$
E. 0



Total Charge = +1.5

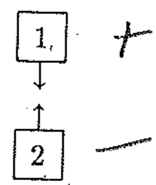
$F_i = \frac{k q_A q_B}{r^2} = \frac{k q^2}{r^2}$



$F_f = \frac{k(.5q)(.75q)}{r^2}$

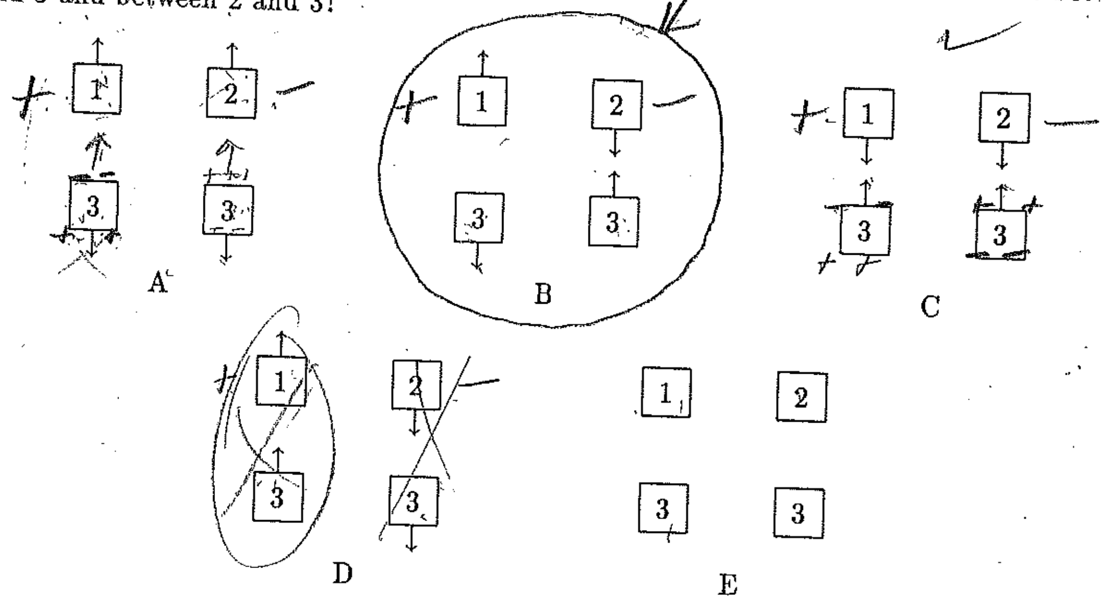
$= \frac{3}{8} \frac{k q^2}{}$

_____ 3. The diagram shows a pair of heavily charged plastic cubes that attract each other.



Possible if cube had + charge on it

Cube 3 is a conductor and is uncharged. Which of the following illustrates the forces between 1 and 3 and between 2 and 3?



_____ 4. A wire contains a steady current of 2 A. The charge that passes a cross section in 2 s is:

A. 3.2×10^{-19} C
B. 6.4×10^{-19} C
C. 1 C
D. 2 C
E. 4 C

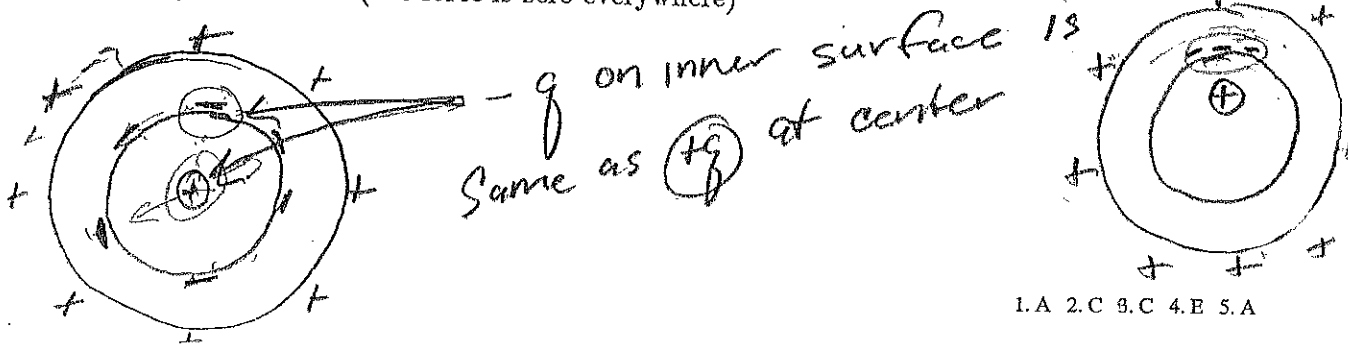
$1\,\text{Amp} = 1\,\frac{C}{s}$ $\quad I = \frac{q}{t}$

$2\,\text{Amp} = 2\,\frac{C}{s}$ $\quad 2 = \frac{q}{2}$

$q = 4$ Coulombs

_____ 5. Charge is distributed on the surface of a spherical conducting shell with a point charge q inside. If polarization effects are negligible the electrical force on q is greatest when:

A. it is near the inside surface of the ~~balloon~~ shell
B. it is at the center of the balloon
C. it is halfway between the balloon center and the inside surface
D. it is anywhere inside (the force is same everywhere and is not zero)
E. it is anywhere inside (the force is zero everywhere)



$-q$ on inner surface is same as $(+q)$ at center

1.A 2.C 3.C 4.E 5.A