HW 3.1 Electrostatic Force Per _____ Name________________________________

1. Two BB's lie 1.5 meters apart on a table. They carry identical charges. How large is the charge on each BB if they each experience an electric force of 2.0 N?

$q \overset{1.5\,m}{\longleftrightarrow} q = ?$

$r = 1.5\,m$

$F_e = 2.0\,N$

$F_e = \frac{k q_1 q_2}{r^2} = \frac{k q^2}{r^2}$

$q = \sqrt{\frac{F_e r^2}{k}} = \sqrt{\frac{(2.0)(1.5)^2}{(9\times10^9)}}$

$2.24\times10^{-5}\,C$

2. A helium nucleus has a charge of +2 e and a neon nucleus has a charge of +10 e. (e = 1.6 E –19 C) Find the repulsion force exerted on one by the other when they are 3 nanometers apart (1 m = 1 E 9 nm).

$q_1 = 2(1.6\times10^{-19})$

$q_2 = 10(1.6E-19)$

$F_e = ?$

$r = 3\times10^{-9}\,m$

$F_e = \frac{k q_1 q_2}{r^2} = \frac{(9\times10^9)(2)(10)(1.6\times10^{-19})^2}{(3\times10^{-9})^2}$

$5.12\times10^{-10}\,N$

3. Explain from an atomic viewpoint why charge is usually transferred by electrons.

protons are found only in nuclei of atoms; electrons are outside and easier to move, take, or replace

4. If a metal object receives a positive (+) charge, what happens to its mass? What happens to the mass if the object is given a negative (-) charge? Explain!

+ charge means losing electrons and therefore mass

– charge means gaining electrons & therefore mass

5. A charged piece of plastic will often attract small bits of paper that fly away when they touch the plastic. Explain why they are attracted and why they fly away.

The charged piece of plastic induces a charge in them which causes attraction. After the paper touches the plastic, charge is conducted to the paper, making both plastic and paper similarly charged → repelled

6. The electron and proton of a hydrogen atom are separated by a distance of about 5.3 E –11 meters. What is the electric force attracting the two particles? What is the gravitational force attracting the two particles?

$q_1 = 1.6\times10^{-19}\,C$

$q_2 = -1.6\times10^{-19}\,C$

$r = 5.3\times10^{-11}\,m$

$F_e = ?$

$F_g = ?$

$m_1 = 1.67\times10^{-27}\,kg$

$m_2 = 9.11\times10^{-31}\,kg$

$F_e = \frac{k|q_1 q_2|}{r^2}$

$F_e = \frac{(9E9)(1.6E-19)^2}{(5.3E-11)^2}$

$F_e = 8.20\times10^{-8}\,N$

$F_g = \frac{G m_1 m_2}{r^2}$

$= \frac{(6.67E-11)(1.67E-27) \times (9.11E-31)}{(5.3E-11)^2}$

$F_g = 3.61\times10^{-47}\,N$

7. If the electric force felt by charged objects is so much more powerful than the gravitational force felt by the same objects, why are you more affected by the gravitational force?

Mass does not transfer readily from like to unlike and we live on a very large mass. Charge balances itself out due to attraction and repulsion, which means we don't have many objects with large charges built up.

7. Two electrostatic point charges of –13.0 µC and –16.0 µC exert repulsive forces on each other of 12.5 N. What is the distance between the two charges?

$q_1 = -13 \times 10^{-6}$ C
$q_2 = -16 \times 10^{-6}$ C
$F_e = 12.5$ N
$r = ?$

$F_e = \frac{k q_1 q_2}{r^2}$

$r = \sqrt{\frac{k q_1 q_2}{F_e}}$

$\sqrt{\frac{(9E9)(-13E-6)(-16E-6)}{12.5}}$

$= 0.387$ m

8. Two electrostatic point charges of –43.2 µC and 22.4 µC exert attractive forces on each other of –6.5 N. What is the distance between the two charges?

$q_1 = -43.2 \times 10^{-6}$ C
$q_2 = 22.4 \times 10^{-6}$ C
$F_e = 6.5$ N
$r = ?$

$r = \sqrt{\frac{k q_1 q_2}{F_e}}$

$= \sqrt{\frac{(9E9)(+43.2E-6)(22.4E-6)}{6.5}} = 1.16$ m

9. Suppose two equal charges are separated by 6.5 E –11 m. If the magnitude of the electric force between the charges is 9.92 E –4 N, what is the value of *q*?

$r = 6.5E-11$
$q_1 = q_2 = ?$
$F_e = 9.92 \times 10^{-4}$

$F_e = \frac{k q^2}{r^2}$

$q = \sqrt{\frac{F_e r^2}{k}}$

$\sqrt{\frac{(9.92 \times 10^{-4})(6.5 \times 10^{-11})^2}{9 \times 10^9}}$

2.16×10^{-17} C

10. List and describe the three methods of transferring charge.

– in notes:

- friction – two things rub together & transfer charge
- induction – charged object pushes/pulls electrons inside uncharged object
- conduction – charge "jumps" from one object to another when they have a difference in charge.

HW 3.2 **E-fields** Per ____ Name________________________________

1. Find the magnitude (size) of the E-field 1 mm from the nucleus of a uranium atom (atomic # 92).

$r = 1\times10^{-3}$ m
$q = 92(1.6\times10^{-19})$ C
$E = ?$

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

$= \frac{(9\times10^9)(92)(1.6\times10^{-19})}{(1\times10^{-3})^2} = \boxed{0.132\ \frac{N}{C}}$

2. The electric **force** on a point charge of 5 E –9 C at some point is 3.8 E –3 N. What is the magnitude (size) of the E-field at this location?

$q = 5\times10^{-9}$ C
$F_e = 3.8\times10^{-3}$ N
$E = ?$

$F_e = q\cdot E$
$E = \frac{F_e}{q}$

$= \frac{3.8\times10^{-3}}{5\times10^{-9}}$

$= \boxed{7.6\times10^{5}\ N/C}$

3. The magnitude of the E-field at a certain location is 500 N / C and the field is directed east to west. Find the magnitude and direction of the force acting on a proton placed at this point.

$E = 500$ N/C
$q = 1.6\times10^{-19}$ C
$F_e = ?$

$F_e = q\cdot E$
$= (1.6\times10^{-19})(500)$
$= \boxed{8\times10^{-17}\ N,\ West}$

4. Find the magnitude and direction of the E-field at a distance 10 cm from an electron.

$E = ?$
$r = 0.1$ m
$q = 1.6\times10^{-19}$ C

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

$E = \frac{(9\times10^9)(1.6\times10^{-19})}{0.1^2}$

$\boxed{1.44\times10^{-7}\ N/C}$

5. The E-field at a distance of 0.8 meters from a certain charge is found to have a magnitude of 200 N / C. What is the magnitude of the charge which created the E-field?

$r = 0.8$ m
$E = 200$ N/C
$q = ?$

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

$q = \frac{E\cdot r^2}{k}$

$\frac{(200)(0.8)^2}{(9\times10^9)}$

$= \boxed{1.42\times10^{-8}\ C}$

6. What is the magnitude of the E-field that will balance the **weight** of an electron?

$F_e = q\cdot E$
$F_g = m\cdot g$

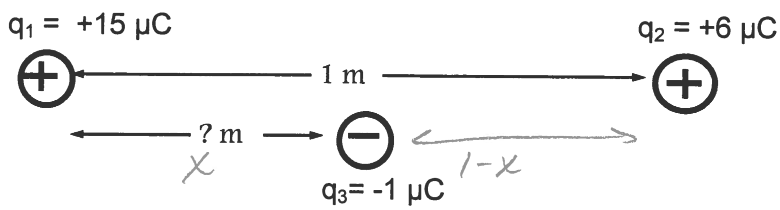
$F_e = F_g$
$q\cdot E = m\cdot g$
$(1.6\times10^{-19})(E) = (9.11\times10^{-31})(9.8)$

$E = \frac{(9.11E{-31})(9.8)}{(1.6E{-19})}$

$= \boxed{5.58\times10^{-11}\ \frac{N}{C}}$

7. Two charges, q_1 and q_2, lie 1 meter apart along the x axis as in the figure below. How far from q_1 should q_3, having a charge of -1 μC, be placed so that the resultant electric **force** on q_3 is zero?

NOT ON TEST!



$15(1-x)^2 = 6x^2$
– graph $15(1-x)^2 - 6x^2$
→ find "zero"

$F_e = F_e$

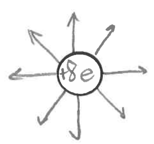
$\frac{Kq_1q_3}{r_{13}^2} = \frac{Kq_2q_3}{r_{23}^2}$

$\frac{q_1}{x^2} = \frac{q_2}{(1-x)^2}$

$\frac{15}{x^2} = \frac{6}{(1-x)^2}$

0.613 m

8. What is the magnitude (size) and direction of the E-field 3 nanometers (nm) away from an Oxygen (+8e; mass 16 amu) nucleus? Draw the E-Field.



$r = 3\times10^{-9}\,m$

$q = 8(1.6\times10^{-19})C$

$E = ?$

$E = \frac{kq}{r^2} = \frac{(9E9)(8)(1.6E-19)}{(3E-9)^2}$

$E = 1.28\times10^{9}\ N/m$

9. What is the magnitude (size) and direction of the force placed on a electron that is 3 nm to the right of the Oxygen nucleus in problem 8 above?

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

$F_e = qE$

$= (1.6\times10^{-19})(1.28\times10^{9})$

$= 2.048\times10^{-10}\ N$ to the left

10. How large of a an electric field would be needed to balance the **WEIGHT** of the Oxygen nucleus?

$m = 16(1.67\times10^{-27})kg$

$F_e = F_g$

$q\cdot E = m\cdot g$

$E = \frac{m\cdot g}{q}$

$\frac{(16)(1.67\times10^{-27})(9.8)}{8(1.6\times10^{-19})}$

$= 2.05\times10^{-7}\ N/C$

11. The E-field at a distance of 8 nanometers from a certain charge is found to have a magnitude of 5.0 E 12 N/C. What is the magnitude of the charge which created the E-field?

$r = 8\times10^{-9}\,m$

$E = 5.0\times10^{12}\ N/C$

$q = ?$

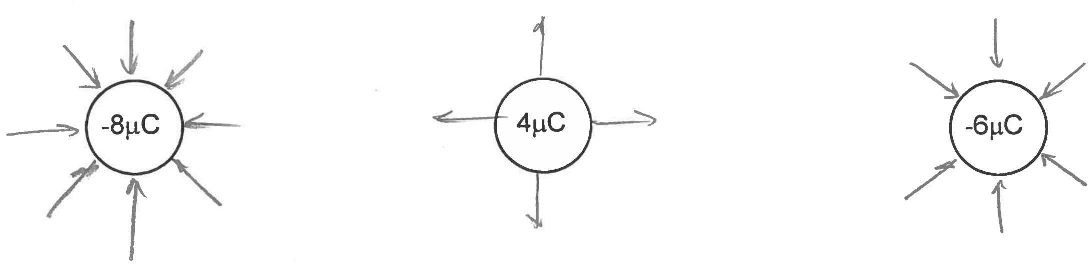
$E = \frac{kq}{r^2}$

$q = \frac{E\cdot r^2}{k}$

$\frac{(5.0E12)(8E-9)^2}{9E9}$

$= 3.5\times10^{-14}\ C$

12. Draw the E-field for each of the following charges:



HW 3.3 **Electrostatics** Per _____ Name_______________________________________

1. How much energy will an electron gain as it moves through a potential difference of 21,000 V in a TV picture tube?

   $\Delta PE = ?$ $\Delta V = 21{,}000\ V$ $q = 1.6\times10^{-19} C$

   $\Delta PE = q\Delta V = (1.6\times10^{-19})(21{,}000) = \boxed{3.36\times10^{-15}\ J}$

2. At what distance from a point charge of +6 **μC** would the potential equal 2.7 E 4 V?

   $q = 6\times10^{-6} C$ $V = 2.7\times10^{4} V$ $r = ?$

   $V = \frac{kq}{r}$ $r = \frac{kq}{V}$ $r = \frac{(9\times10^{9})(6\times10^{-6})}{2.7\times10^{4}} = \boxed{2\ m}$

3. Find the potential at a distance 1 **cm** from a proton.

   $V = ?$ $r = 0.01 m$ $q = 1.6\times10^{-19} C$

   $V = \frac{kq}{r} = \frac{(9E9)(1.6E-19)}{0.01} = \boxed{1.44\times10^{-7}}$

4. In the Bohr model of the hydrogen atom an electron circles a proton in an orbit of radius 5.1 E –11 meters. Find the voltage at this position.

   $q = 1.6\times10^{-19} C$ $r = 5.1\times10^{-11} m$ $V = ?$

   $V = \frac{kq}{r}$ $V = \frac{(9E9)(1.6E-19)}{(5.1E-11)} = \boxed{28.24\ V}$

5. A point charge of 9 E –9 C is located at the origin. How much work is required to bring a proton from Pflugerville to a distance of 30 **cm** away from the point charge?

   $q_1 = 9\times10^{-9} C$ $W = ?$ $r = 0.3 m$ $q_2 = 1.6\times10^{-19}$

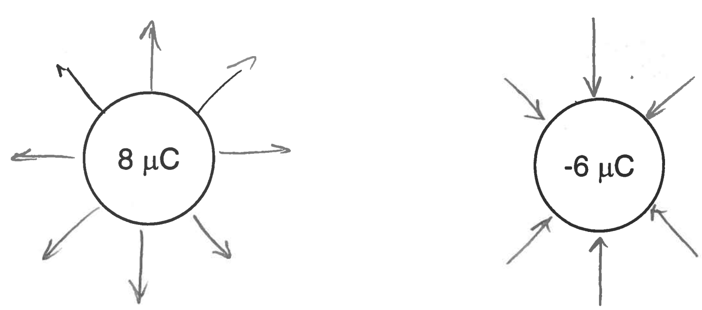
   $W = \Delta PE_e = q\Delta V = q_2\left(\frac{kq_1}{r_2} - \frac{kq_1}{r_1}\right)$ $(1.6E-19)\left(\frac{(9E9)(9E-9)}{0.3}\right) = \boxed{4.32\times10^{-17} J}$

6. What is the magnitude of the E-field 10 nm from a Carbon nucleus?

   $E = ?$ $r = 10\times10^{-9} m$ $q = 6(1.6\times10^{-19}) C$

   $E = \frac{kq}{r^2} = \frac{(9E9)(6)(1.6E-19)}{(10E-9)^2} = \boxed{8.64\times10^{7}\ \frac{N}{C}}$

7. Draw appropriate E-field lines for the point charges shown below.



8. What is the voltage 10 nm from a Carbon nucleus?

$V = ?$

$r = 10 \times 10^{-9}$ m

$q = 6(1.6 \times 10^{-19})$ C

$V = \frac{kq}{r} = \frac{(9E9)(6)(1.6E-19)}{10E-9}$

$= 0.864$ V

(or $V = E \cdot r$)

9. What is the magnitude and direction of an E-field that just balances a suspended electron?

$F_e = F_g$

$q \cdot E = m \cdot g$

$E = \frac{m \cdot g}{q}$

$\frac{(9.11E-31)(9.8)}{(1.6E-19)}$

$= 5.58 \times 10^{-11}$ N/C downward!

10. How close can an electron moving 3.2 E 6 m/s get to a stationary –18 ρC charge?

$q_2 = 1.6E-19$ C

$v = 3.2E6$ m/s

$q_1 = -18 \times 10^{-12}$ C

$m_2 = 9.11E-31$ kg

KE to PE

$\frac{1}{2}mv^2 = q\Delta V = \frac{kq_1q_2}{r}$

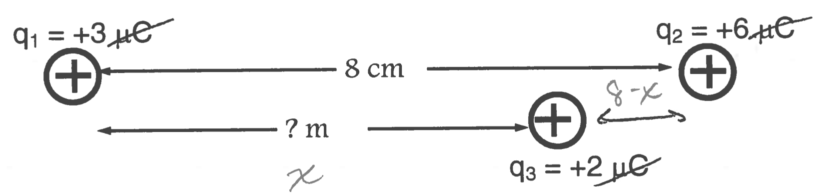
$r = \frac{2kq_1q_2}{mv^2} = \frac{2(9E9)(18E-12)(1.6E-19)}{(9.11E-31)(3.2E6)^2}$

0.00556 m

or

5.56×10^{-3} m

11. Three point charges, q_1, q_2, and q_3 lie along the x-axis as shown in the picture below. How far from q_1 would q_3 need to be placed in order for it to feel no resultant electric force?



$F_e = F_e$

$\frac{kq_1q_3}{r^2} = \frac{kq_2q_3}{r^2}$

$\frac{q_1}{r_{13}^2} = \frac{q_2}{r_{23}^2}$

$\frac{3}{(x)^2} = \frac{6}{(8-x)^2}$

$3(8-x)^2 = 6x^2$

$(8-x)^2 = 2x^2$

$64 - 16x + x^2 = 2x^2$

$64 - 16x - x^2 = 0$ → graph & find zero → 3.314 cm