HW01 (CH26 Electric Charges and Forces)

Due: 11:59pm on Wednesday, January 26, 2011

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Note: To understand how points are awarded, read your instructor's Grading Policy.

Problem 26.4

Description: A glass rod that has been charged to + q_1 touches a metal sphere. Afterward, the rod's charge is + q_2. (a) What kind of charged particle was transferred between the rod and the sphere, and in which direction? That is, did it move from the rod ...

A glass rod that has been charged to $+\ 11.0\ \text{nC}$ touches a metal sphere. Afterward, the rod's charge is $+\ 3.0\ \text{nC}$.

Part A

What kind of charged particle was transferred between the rod and the sphere, and in which direction? That is, did it move from the rod to the sphere or from the sphere to the rod?

ANSWER:

- **electrons, from the sphere to the rod**
- **protons, from the rod to the sphere**
- **protons, from the sphere to the rod**
- **electrons, from the rod to the sphere**

Part B

How many charged particles were transferred?

Express your answer using two significant figures.

ANSWER:

$N = \dfrac{q_1 - q_2}{1.6 \cdot 10^{-19}}$ particles

Problem 26.6

Description: (a) What is the total charge of all the electrons in V of liquid water?

Part A

What is the total charge of all the electrons in 1.7 L of liquid water?

Express your answer using two significant figures.

ANSWER:

$q = \dfrac{10V \cdot 1000 \cdot 6.02 \cdot 10^{23} \cdot 1.6 \cdot 10^{-19}}{18}$ C

Problem 26.21

Description: The electric field at a point in space is E_vec = (E_x i_unit+ E_y j_unit) N/C. (a) What is the x-component of the electric force on a proton at this point? (b) What is the y-component of the electric force on a proton at this...

The electric field at a point in space is $\vec{E} = (\ 600\ \hat{i} + 700\ \hat{j})\ \text{N/C}$.

Part A

What is the *x*-component of the electric force on a proton at this point?

Express your answer numerically, in newtons, to three significant figures.

ANSWER:

$(\vec{F})_x = E_x \cdot 1.6\left(10^{-19}\right)$ N

Part B

What is the *y*-component of the electric force on a proton at this point?

Express your answer numerically, in newtons, to three significant figures.

ANSWER: $(\vec{F})_y = E_y \cdot 1.6 \cdot 10^{-19}$ N

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Part C

What is the *x*-component of the electric force on an electron at this point?

Express your answer numerically, in newtons, to three significant figures.

ANSWER: $(\vec{F})_x = (-1)\, E_x \cdot 1.6 \cdot 10^{-19}$ N

Part D

What is the *y*-component of the electric force on a electron at this point?

Express your answer numerically, in newtons, to three significant figures.

ANSWER: $(\vec{F})_y = (-1)\, E_y \cdot 1.6 \cdot 10^{-19}$ N

Part E

What is the magnitude of the proton's acceleration?

Express your answer numerically, in meters per second squared, to three significant figures.

ANSWER: $a_p = \dfrac{\sqrt{\left(E_x^{\,2} + E_y^{\,2}\right)} \cdot 1.6 \cdot 10^{-19}}{1.67 \cdot 10^{-27}}$ m/s^2

Part F

What is the magnitude of the electron's acceleration?

Express your answer numerically, in meters per second squared, to three significant figures.

ANSWER: $a_e = \dfrac{\sqrt{\left(E_x^{\,2} + E_y^{\,2}\right)} \cdot 1.6 \cdot 10^{-19}}{9.11 \cdot 10^{-31}}$ m/s^2

Problem 26.32

Description: A m_plastic plastic bead charged to q_plastic and a m_glass glass bead charged to q_glass are l apart (center to center). (a) What are the magnitudes of the accelerations of the plastic bead and the glass bead? (b) What are the directions of the...

A 1.7 g plastic bead charged to -3.7 nC and a 4.1 g glass bead charged to 17.1 nC are 1.8 cm apart (center to center).

Part A

What are the magnitudes of the accelerations of the plastic bead and the glass bead?

Express your answers using two significant figures. Enter your answers numerically separated by a comma.

ANSWER: $a_{plastic},\ a_{glass} = \dfrac{9 \cdot 10^9 \left|q_{plastic}\right| q_{glass}}{l^2 m_{plastic}},\ \dfrac{9 \cdot 10^9 \left|q_{plastic}\right| q_{glass}}{l^2 m_{glass}}$ m/s^2

Part B

What are the directions of the accelerations of the plastic bead and the glass bead?

ANSWER:

- The beads are moved in the same direction.
- **The beads are attracted to one another.**
- The beads are repulsed to one another.

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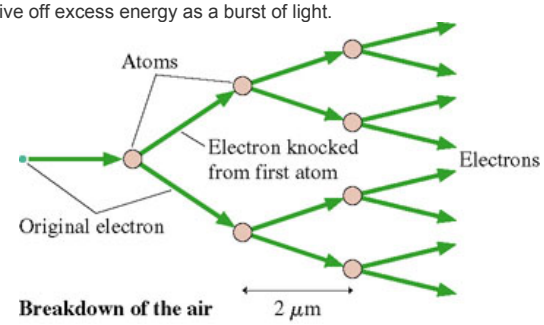
Problem 26.58

Description: (a) The average distance an electron travels between collisions is 2.0 mu m. What acceleration must an electron have to gain 2.0 * 10^(- 18) J of kinetic energy in this distance? (b) What force must act on an electron to give it the acceleration...

You sometimes create a spark when you touch a doorknob after shuffling your feet on a carpet. Why? The air always has a few free electrons that have been kicked out of atoms by cosmic rays. If an electric field is present, a free electron is accelerated until it collides with an air molecule. It will transfer its kinetic energy to the molecule, then accelerate, then collide, then accelerate, collide, and so on. If the electron's kinetic energy just before a collision is 2.0×10^{-18} J or more, it has sufficient energy to kick an electron out of the molecule it hits. Where there was one free electron, now there are two! Each of these can then accelerate, hit a molecule, and kick out another electron. Then there will be four free electrons. In other words, as the figure shows, a sufficiently strong electric field causes a "chain reaction" of electron production. This is called a *breakdown* of the air. The current of moving electrons is what gives you the shock, and a spark is generated when the electrons recombine with the positive ions and give off excess energy as a burst of light.



Part A

The average distance an electron travels between collisions is $2.0\mu m$. What acceleration must an electron have to gain 2.0×10^{-18} J of kinetic energy in this distance?

ANSWER: $1.10 \cdot 10^{12}$ m/s^2

Part B

What force must act on an electron to give it the acceleration found in part a?

ANSWER: $1.00 \cdot 10^{-12}$ N

Part C

What strength electric field will exert this much force on an electron? This is the *breakdown field strength.*

ANSWER: $6.25 \cdot 10^{6}$ N/C

Part D

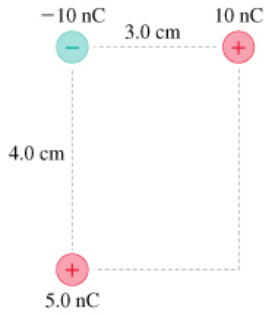
Suppose a free electron in air is 1.0 cm away from a point charge. What minimum charge q_{min} must this point charge have to cause a breakdown of the air and create a spark?

ANSWER: 69.4 nC

Problem 26.42

Description: (a) What is the force F_vec on the 5.0 nC charge in the figure? Give your answer as a magnitude and an angle measured ccw from the +x-axis. (b) ...

Part A



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What is the force $\vec{F}$ on the 5.0 nC charge in the figure? Give your answer as a magnitude and an angle measured ccw from the $+x$-axis.

Express your answer using two significant figures.

ANSWER:

F = $1.7 \cdot 10^{-4}$ N

Part B

Express your answer using three significant figures.

ANSWER:

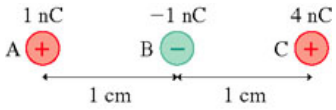
θ = 128 ° counterclockwise from the $+x$-axis

Problem 26.16

Description: (a) What is the net electric force on charge A in the figure ?

Part A

What is the net electric force on charge A in the figure ?

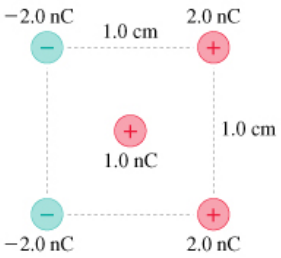


ANSWER:

0 N

Problem 26.44

Description: (a) What is the force F_vec on the 1.0nC charge in the middle of the figure due to the four other charges? Give your answer in component form.



Part A

What is the force $\vec{F}$ on the 1.0nC charge in the middle of the figure due to the four other charges? Give your answer in component form.

Assume that x-axis is directed horizontally to the right, and y-axis is directed vertically upward.

ANSWER:

F_x, F_y = $\begin{matrix} -1.02 \cdot 10^{-3} \\ 0 \end{matrix}$ N

Problem 26.48

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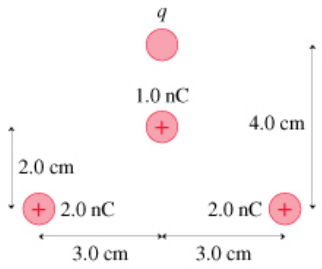
Description: The net force on the 1.0 nC in the figure charge is zero. (a) What is q?

The net force on the 1.0 nC in the figure charge is zero.



Part A

What is q?

Express your answer using two significant figures.

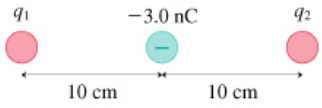
ANSWER:

q = 0.68 nC

Problem 26.49

Description: Charge q_2 in the figure is in static equilibrium. (a) What is q_1?

Charge q_2 in the figure is in static equilibrium.



Part A

What is q_1?

Express your answer using two significant figures.

ANSWER:

q_1 = 12 nC

Problem 26.68

Description: An electric field E_vec = E imath_unit (N/C) causes the point charge in the figure to hang at an angle. (a) What is theta ?

An electric field $\vec{E} = 7.00 \times 10^{3}\hat{i}\ \text{N/C}$ causes the point charge in the figure to hang at an angle.

Part A

What is θ?

Hint A.1 **Force diagram**

The only forces acting on the ball are gravity, electric force, and the tension in the string. Since the ball has no acceleration, the tension in the string must exactly cancel the net force from the other two forces.

Express your answer using two significant figures.

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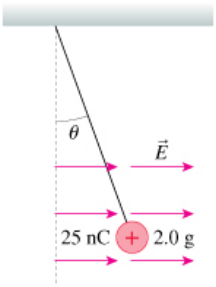


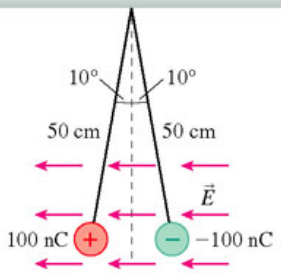
ANSWER:

$$\theta = \frac{180\tan\left(\frac{25(10^{-9})E}{0.002\cdot 9.8}\right)}{\pi} \quad ^\circ$$

Problem 26.75

Description: The identical small spheres shown in the figure are charged to +100 nC and -100 nC. They hang as shown in a E electric field. (a) What is the mass of each sphere?

The identical small spheres shown in the figure are charged to +100 nC and -100 nC. They hang as shown in a 1.00×10^5 N/C electric field.



Part A

What is the mass of each sphere?

Hint A.1 **How to approach this problem**

Since all of the electric forces only have horizontal components, we know that the horizontal component of the tension in the string must cancel this net force since the balls are not accelerating. If we know the tension, we can figure out its component in the vertical direction, which can only be canceled by gravity.

ANSWER:

$$\frac{1000\left(E\cdot 100\cdot 10^{-9}-\frac{9\cdot 10^9\left(100\cdot 10^{-9}\right)^2}{\left(2\cdot 0.5\sin\left(\frac{10\pi}{180}\right)\right)^2}\right)}{9.8\tan\left(\frac{10\pi}{180}\right)} \quad \text{g}$$

Score Summary:

Your score on this assignment is 0%.
You received 0 out of a possible total of 120 points.