PHYSICS IN MOTION
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Unit 5B
Static Electricity
Practice Problems

Name:

Date:

Work each of the following problems. SHOW ALL WORK.

1. **Determine the number of electrons or protons that are found in the following:**

   a. **+1 C of charge**

   The charge of one proton is 1.6 x 10^{-19} C. Therefore, the number of protons in +1 C of charge is:

$$\frac{1C}{1.6 \times 10^{-19}\,C} = 6.3 \times 10^{18}$$

   b. **-1 C of charge**

   The charge of one electron is -1.6x10^{-19} C. Therefore, the number of electrons in -1 C of charge is:

$$\frac{-1C}{-1.6 \times 10^{-19}\,C} = 6.3 \times 10^{18}$$

   c. **-1.6 x 10^{-6} C of charge**

   This charge is negative due to electrons.

$$\frac{-1.6 \times 10^{-6}\,C}{-1.6 \times 10^{-19}\,C} = 1 \times 10^{13}\ electrons$$

2. **A metal ball has a net charge of 4.5 x 10^{-7} C.**

   a. **What is the relative number of protons and electrons in the ball?**

   Since the ball is positively charged, it has more protons than electrons. To determine the number of protons in the ball, divide the ball's net charge by the charge of a proton (1.6 x 10^{-19} C):

$$\frac{4.5 \times 10^{-7}\,C}{1.6 \times 10^{-19}\,C} = 2.8 \times 10^{12}\ protons\ in\ the\ ball$$

   b. **If just enough charge is removed to make the ball neutral, how much mass does it lose?**

   To determine how much mass the ball will lose if it becomes neutral, multiply the number of protons in the ball by the mass of a proton (1.6 x 10^{-27} kg):

$$(2.8 \times 10^{12}\ protons)(1.6 \times 10^{-27}\ kg) = 4.5 \times 10^{-15}\ kg$$

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3. **An uncharged spherical conductor hangs by an insulating thread. If you place a negatively charged rod near one side of the conductor, what is the net charge of the sphere?**

   a. positive

   b. *negative*

   c. neutral

The conductor's exposed side has a net positive charge due to charge polarization by the negatively charged rod. However, the overall charge of the sphere remains neutral since the two objects have not touched and therefore charge has neither been added nor taken away.

4. **Two objects with negative charges of 6.2 nC each are separated by a distance of 0.3 m. What is the size and direction of the force between the two charges?**

Since the charges have the same (negative) sign, they will repel each other.

The size or magnitude of the force between them is determined by Coulomb's law:

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

$$q_1 = -6.2 \times 10^{-9}\ C$$
$$q_2 = -6.2 \times 10^{-9}\ C$$
$$r = 0.3\ m$$
$$k = 9 \times 10^{9}\ C^2N/m^2$$

$$F_{electric} = \frac{(9 \times 10^{9}\ C^2N/m^2)|(-6.2 \times 10^{-9}\ C)(-6.2 \times 10^{-9}\ C)|}{(0.3\ m)^2}$$
$$F_{electric} = 3.8 \times 10^{-6}\ N$$

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5. **An object with a negative charge of 1.2 mC exerts an attractive force of 13.6 N on a second charged object that is positioned 0.072 m away. What is the charge and polarity (positive or negative) of the second object?**

First, rearrange Coulomb's law to solve for the magnitude of the charge of the second object:

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

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

Next, solve for q_2:

$$F_{electric} = 13.6\,N$$
$$r = 0.072\,m$$
$$q_1 = -1.2 \times 10^{-3}\,C$$

$$|q_2| = \frac{(13.6\,N)(0.072\,m)^2}{(9 \times 10^9\,C^2N/m^2)|-1.2 \times 10^{-3}\,C|}$$
$$|q_2| = 6.5 \times 10^{-9}\,C$$

The first object (q_1) is negative and exerts an attractive force on the second object (q_2).

The second object has a positive charge of magnitude 6.5×10^{-9} C.

6. **How many excess electrons are in a ball with a charge of -5.31×10^{-16} C?**

Divide the total charge of the ball (-5.31×10^{-16} C) by the individual charge of an electron (-1.6×10^{-19} C) to determine the number of excess electrons in the ball:

$$\frac{-5.31 \times 10^{-16}\,C}{-1.6 \times 10^{-19}\,C} = 3.3 \times 10^3 \text{ electrons}$$

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7. **A metal ball with a charge of -8 nC contacts a second metal ball and loses half its excess electrons. What force does the second metal ball exert on a proton 6 m away?**

The second ball acquires a charge of -4 x 10^{-9} C.

Solve for the electric force magnitude between the second ball and the proton using Coulomb's law:

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

$$k = 9 \times 10^9\ C^2N/m^2$$
$$q_1 = -4 \times 10^{-9}\ C$$
$$q_2 = -1.6 \times 10^{-19}\ C$$
$$r = 6\ m$$

$$F_{electric} = \frac{(9 \times 10^9\ C^2N/m^2)|(-4 \times 10^{-9}\ C)(-1.6 \times 10^{-19}\ C)|}{(6\ m)^2}$$
$$F_{electric} = 1.6 \times 10^{-19}\ N$$

This is an attractive force because the second ball and the proton have unlike polarity.

8. **Rubbing a plastic bag and a balloon with a cloth gives both objects a net negative charge. The balloon's charge is -1 x 10^{-10} C, the bag's charge is -1 x 10^{-5} C, and each object has a mass of 0.02 g. While wearing insulating gloves, you hold the bag above the balloon and release it. How far above the center of the balloon will the bag "levitate"?**

Determine the distance at which the electrical force of repulsion between the bag and the balloon equals the downward force of gravity on the bag.

$$F_{gravity} = F_{electric}$$
$$m_{bag}\, g = \frac{k|q_{balloon}\, q_{bag}|}{r^2}$$

Solve for the distance (r):

$$r^2 = \frac{k|q_{balloon}\, q_{bag}|}{m_{bag}\, g}$$

$$r = \sqrt{\frac{k|q_{balloon}\, q_{bag}|}{m_{bag}\, g}}$$

$$r = \sqrt{\frac{(9 \times 10^9\ C^2N/m^2|(-1 \times 10^{-10}\ C)(-1 \times 10^{-5}\ C)|}{(2 \times 10^{-5}\ kg)(9.8\ m/s^2)}}$$

$$r = 0.21\,m$$