Name:___________________________ Points:___/10

SMITH - INDUSTRIAL SCIENCE B – 3RD PERIOD - OFF-SITE LEARNING PACKET DAY 2

Chapter 9 Electricity
Lesson 2 – Electric Charge

Lesson Objectives

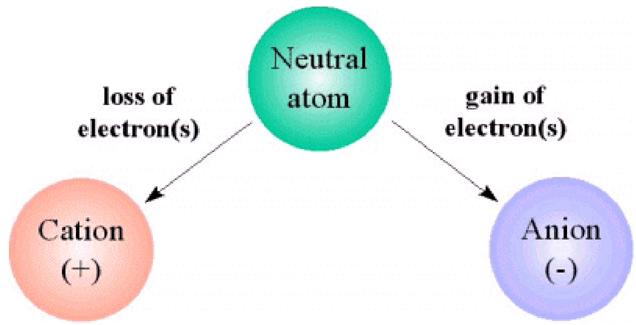
- **define the bellwork vocabulary words (ion, coulomb)**
- **state conservation of charge principle**
- **define Coulomb's law for electrical force, including all terms ($F_{electrical}$, k, q_1,q_2,d)**

Associated Text:
Chapter 9 Lesson 2

Charles Coulomb quantified the force between charged particles.

Ionization

Normally, an atom has as many electrons as protons. When these two charges are balanced we say that the atom is a neutral atom. Atoms can lose or gain electrons through a variety of processes. When an atom loses one or more electrons, it has a positive net charge, and when it gains one or more electrons, it has a negative charge. A charged atom is called an **ion**. The process of creating an ion is called **ionization**. A positive ion (also called a **cation**) has a net positive charge. A negative ion (also called an **anion**), with one or more extra electrons, has a net negative charge. An important concept here is that ions, whether positive or negative, are created by the removal or addition of electrons only, changing the protons in an atom is called transmutation and involves concepts totally different than ionization.



Charged atoms, ions, are formed from the removal or addition of electrons.

Charged Objects

The plastic in the comb attracts electrons more than the hair, and when you comb your hair, friction causes electrons to be rubbed off the hair and onto the comb.

Material objects are made of atoms, which means they are composed of electrons and protons (and neutrons). Objects ordinarily have equal numbers of electrons and protons and are therefore electrically neutral. But if there is a slight imbalance in the numbers, the object is electrically charged.

Objects themselves can be electrically charged. An imbalance comes about when electrons are added to or removed from an object. Although electrons closest to the atomic nucleus, the innermost electrons, are bound very tightly to the oppositely charged atomic nucleus, the electrons farthest from the nucleus, the outermost electrons, are bound very loosely and can be easily dislodged.

How easy it is to remove electrons from an atom varies from one substance to another. The electrons are held tighter in rubber and plastic than in your hair, for example. When a comb is passed through your hair, friction causes electrons to transfer from your hair to the comb. The comb then has an excess of electrons and is said to be negatively charged. Your hair, in turn, has a deficiency of electrons and is said to be positively charged. To take another example, if you rub a glass or plastic rod with silk, the rod becomes positively charged. Silk has a greater affinity for electrons than does glass or plastic. Electrons are therefore rubbed off the rod and onto the silk.

So we see that an object having unequal numbers of electrons and protons is electrically charged. If it has more electrons than protons, it is negatively charged. If it has fewer electrons than protons, it is positively charged.

Conservation of Charge

It is important to note that when we charge something, no electrons are created or destroyed. They are simply transferred from one material to another. Charge is conserved. In every event, whether large-scale or at the atomic and nuclear level, the principle of conservation of charge has always been found to apply. No case of the creation or destruction of net electric charge has ever been found. Conservation of charge ranks with conservation of energy and momentum as a significant fundamental principle in physics.

Coulomb's Law

The electric force, like the gravitational force between two masses, is **inversely proportional** to the square of the distance between charged particles. It increases as the particle-to-particle distance decreases and decreases as the distance increases. This relationship was discovered by Charles Coulomb in the eighteenth century and is called **Coulomb's law**. It states that for two charged particles or objects that are much smaller than the distance between them, the force between the two varies directly as the product of their charged and inversely as the square of the separation distance. The force acts along a straight line from one charged particle to the other . Coulomb's law can be expressed:

$$F = k\frac{q_1 q_2}{d^2}$$

where k is the proportionality constant, q_1 represents the quantity of charge on one particle, q_2 represents the quantity of charge of the other particle, and d is the distance between the charged particles.

The standard unit of charge is the **coulomb**, abbreviated C. It turns out that a charge of 1 coulomb is the charge associated with 6.25 billion billion electrons (6.25×10^{18}). This might seem like a great number of electrons, but it represents only the amount of charge that passes through a common 100 watt light bulb in a little over a second.

6,250,000,000,000,000,000 electrons flow through a 100 watt light bulb every second. That is a coulomb of charge.

The proportionality constant *k* in Coulomb's law is similar to *G* in Newton's law of universal gravitation. Instead of being a very small number like *G* (6.67×10^{-11}), *k* is a very large number, approximately

$k = 9{,}000{,}000{,}000\ N \cdot m^2/C^2$

or, in scientific notation, $k = 9 \times 10^9\ N \cdot m^2/C^2$. The unit $N \cdot m^2/C^2$ is not central to our interest here; it simply converts the right-hand side of the equation to the unit of force, the newton (N). What is important is the large magnitude of k. If, for example, a pair of like charged particles each carrying a charge of 1 coulomb were 1 meter apart, the force of repulsion between them would be 9 billion newtons. That would be about ten times the weight of a battleship. Obviously, such amount of net charge do not usually exist in our everyday environment.

Contrast this enormous value to the gravitational force of attraction between two kilogram masses 1 meter apart: 6.67×10^{-11} N. This is an extremely small force. For the gravitational force to be 1 N, the masses 1 meter apart would have a mass of 123,000 kg each. Gravitational forces between ordinary objects are exceedingly small, and electrical forces (non-canceled) between ordinary objects are exceedingly huge. We don't sense them because the positives and the negatives normally balance out, and even for highly charged objects, the imbalance of electrons to protons is normally less than one part in a trillion trillion.

So Newton's law of gravitation for masses is similar to Coulomb's law for electrically charged bodies. Whereas the gravitational force of attraction between particles such as an electron and a proton is extremely small, the electric force between these particles is relatively enormous. Other than the big difference in strength, the most important difference between gravitational and electric forces is that electric forces may be either attractive or repulsive, whereas gravitational forces are only attractive.

If you could separate just on coulomb of electrons from protons by one meter, the force of attraction would be equal to more than the weight of 10 battleships.

Image URLs

http://ritterlumber.net/wp-content/uploads/2013/12/incandescent-lightbulb.jpg
http://web2.gyldendal.no/undervisning/felles/pixdir20/data/archive_specific/aqua1/image_fullsize/02_02_091668.jpg
http://www.mstworkbooks.co.za/natural-sciences/gr8/images/gr8ec01-gd-0003.png
https://upload.wikimedia.org/wikipedia/commons/thumb/5/5c/New_Jersey_Sails.jpg/1200px-New_Jersey_Sails.jpg

Guided Reading Questions: ***(10 pts.)***

use the chapter text and guided notes found above

Ionization

1. How does the number of protons in the atomic nucleus normally compare with the number of electrons that orbit the nucleus?

2. What is an ion?

3. What subatomic particle is lost or gained to make an ion?

4. What is another name for a positively charged ion?

5. What is another name for a negatively charged ion?

Charged Objects

6. Do all materials attract electrons with equal strengths?

7. When you comb your hair, electrons are transferred from your hair to the comb. What force is involved in this transfer?

8. What kind of charge does an object acquire when electrons are stripped from i

Conservation of Charge

9. What is the law of conservation of charge?

Coulombs Law

10. What is the standard unit of charge in physics?

11. How does a coulomb of charge compare with the charge of a single electron?

12. Write Coulomb's law. What do the following terms indicate:

q_1 -

q_2 -

k -

d -

13. How does the magnitude of electric force between a pair of charged particles change when the particles are moved twice as far apart? Three times as far apart?

14. Other than the fact that the electrical force is much, much stronger than the gravity force, what is the other difference between the gravity force and the electrical force?

Lesson Notes

Ions

- ion: a charged atom
- normally atoms are not charged
  - atoms can become charged only by losing or gaining ELECTRONS
- symbolically
  - Fe^{+2} : iron atom with two missing electrons
  - Fe^{-2} : iron atom with two extra electrons

Charged Objects

- objects can be electrically charged by adding or removing electrons
- adding or removing electrons takes WORK (F x d)
- the amount of work varies with different materials

Conservation of Charge

- when we charge something no electrons are created or destroyed
- conservation of charge ranks with conservation of energy and momentum as a significant fundamental principle in physics.

Coulomb's Law

- quantifies the force between two charged particles
  - $F_{electrical} = k\frac{q_1 q_2}{d^2}$
- q_1, q_2 : amount of charge
- k : constant (relatively large)
- d : distance between particles

Coulomb

- unit of charge
- symbolically: C
- equal to 6.25×10^{18} electrons
- charge going through 100 watt light bulb per second

Newton's Law of Gravitation and Coulomb's Law

- electrical force is billions of times stronger
- electrical force has both attractive and repulsive force, gravity only attracts

$$F_{electrical} = k\frac{q_1 q_2}{d^2} \qquad F_{gravity} = G\frac{m_1 m_2}{d^2}$$

Vocabulary

ion – a charged atom, can be positive or negative
Coulomb – the unit of charge