IMPORTANT TERMS:

- **Charge**
- **Conductor**
- **Conservation of charge**
- **Coulomb**
- **Coulomb's Law**
- **Electrical force**
- **Electrically polarized**
- **Electrostatics**
- **Grounding**
- **Induced**
- **Induction**
- **Insulator**
- **Semiconductor**
- **superconductor**

EQUATIONS:

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

UNIT V: Electricity and Magnetism

Chapters 32-37

Chapter 32: Electrostatics

I. Electrical Forces and Charges (32.1)

A. **Electrostatics**- electricity at rest (Involves electric charges, forces between them, and their behavior in materials)

B. Electrical forces

1. arise from **particles** in atoms

2. Occur as **pair** of **forces** acting on you at all times

a. **Attracting** and **repelling** forces

b. This force attributed to property called **charge**

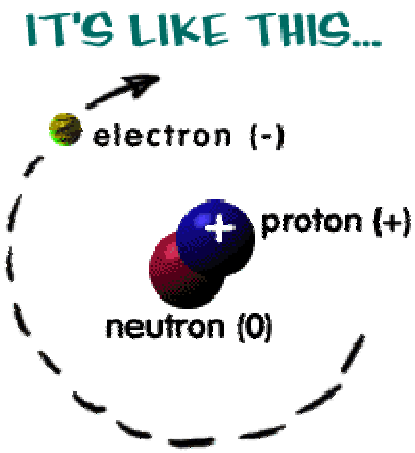
1). **Electrons**- negative charge

2). **Protons**- positive charge

3). **Neutrons**- neutral charge

3. Much **stronger** than gravitational force

C. **Atoms**



1. Every atom has **positively charged nucleus** surrounded by **negatively charged electrons**

2. All **electrons** are **identical** (same **mass** and **quantity** of negative charge)

3. **Nucleus** composed of **protons** and **neutrons**.

a. all protons are **identical**

b. all neutrons **identical**

c. Proton has mass 2000 times **greater** than electron

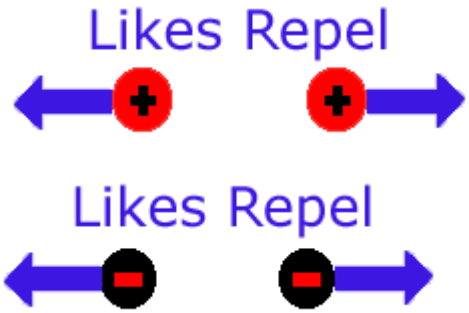
d. positive charge of proton **equal** in **magnitude** to negative charge of electron.

e. neutron has mass slightly greater than proton and has **no charge**

4. Atoms usually have as many electrons as protons, so atom has a **zero net charge**

5. Fundamental rule at the base of all electrical phenomena is:

Like charges repel; opposite charges attract



II. Conservation of Charge (32.2)

A. Electrons and protons have electric charge

1. **Neutral atom**- <u>electrons</u> **equal** <u>protons</u> (no net charge)

2. If electron removed atom no longer neutral- would have one extra proton and be positively charged

3. **Ion**- a **charged atom**

a. **positive ion**- has net positive charge (it has lost one or more electrons)

b. **negative ion**- has net negative charge (it has gained one or more extra electrons)

B. Electrical charge

1. **Matter** made of **atoms**

2. **imbalance** in numbers cause object to be **electrically charged**

C. Electrons

1. **Inner electrons** bound **tightly** to oppositely charged nucleus

2. **Outermost electrons**- **loosely bound** and can be easily dislodged.

3. Different materials require varying amounts of energy to tear an electron away from an atom

4. An object with unequal numbers of electrons and protons is **electrically charged** (either negatively or

positively)

D. **Conservation of charge**

1. **Electrons are neither created nor destroyed**

a. They are simply **transferred** from one material to another

2. **Charge is conserved** (cornerstone of physics along with **conservation of energy and momentum**)

III. Coulomb's Law (32.3)

A. Explains the electrical force between any two objects

1. Similar to Newton's Law of Gravitation

2. Obeys **inverse-square relationship** with **distance**

3. Discovered by French physicist **Charles Coulomb** (1736-1806)

B. **Coulomb's Law**- states that for **charged particles** or **objects** that are small compared to the distances between them, the **force** between the charges **varies directly** as the **product of the charges** and **inversely** as the **square of the distance** between them

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

d = distance between charged particles
q_1 = quantity of charge of one particle
q_2 = quantity of charge of other particle
k = proportionality constant

1. SI unit of charge is the **coulomb (C)**

a. **One coulomb** = charge of 6.24 billion billion electrons (**6.24 X 10^{18} electrons**)

b. Amount of charge that passes through common 1--W light bulb in about one second

2. **Proportionality constant** (**k**) in Coulomb's law is similar to **G** in New-

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

$$k = 9.0x10^9 N \cdot m^2 / C^2$$

ton's law of gravitation.

a. Unlike (G) in gravitation equation, (**k**) is a very **large number**

b. Biggest difference between gravitation and electrical forces is that while **gravity only attracts**, **electrical forces may either attract or repel**.

C. Electrical forces usually **balance out**.

1. Weak gravitational force (attractive only) is predominant force between astronomical bodies

2. **Atomic level**- explains the bonding of atoms to form molecules

IV. Conductors and Insulators (32.4)

A. **Conductor**-materials that have more loosely bound outer electrons that can roam in the material

1. **Metals** are <u>good</u> **conductors of electricity**

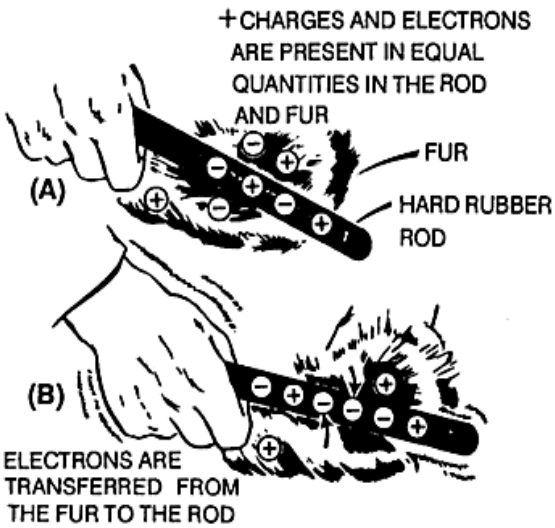
2. Also <u>good</u> **conductors of heat**

B. **Insulator**- Materials whose electrons are not free to wander

1. Also <u>poor</u> **conductors of heat**

2. **Rubber** and **glass** good insulators

C. **Semi-conductors**- materials that can be made to behave as either conductor or insulator (thin layers of semi-conducting materials sandwiched together make up **transistors**)

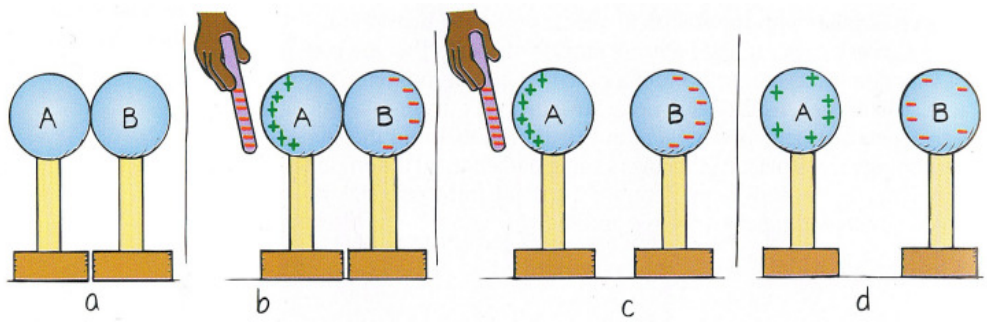


D. **Su-**

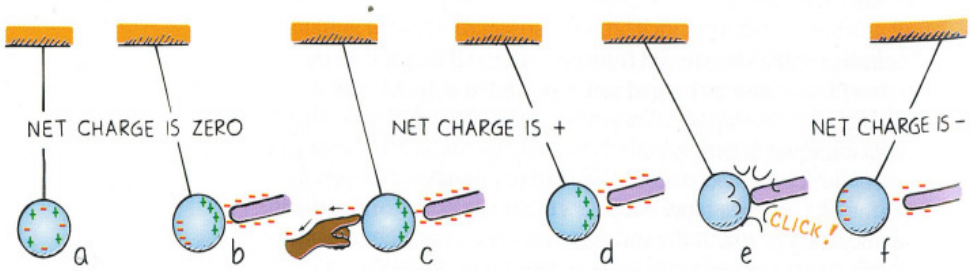
perconductors- materials that acquire infinite conductivity
(At temperature near absolute zero, certain metals become superconductors)

V. Charging by Friction and Contact (32.5)

A. **Charging by Friction**- can transfer electrons when one



material rubs against another



B. **Charging by Contact**- can transfer charge by touching charged object to neutral object

VI. Charging by Induction (32.6)

A. **Electrons** are caused to <u>gather</u> or <u>disperse</u> by the presence of a nearby charge (even without physical contact)

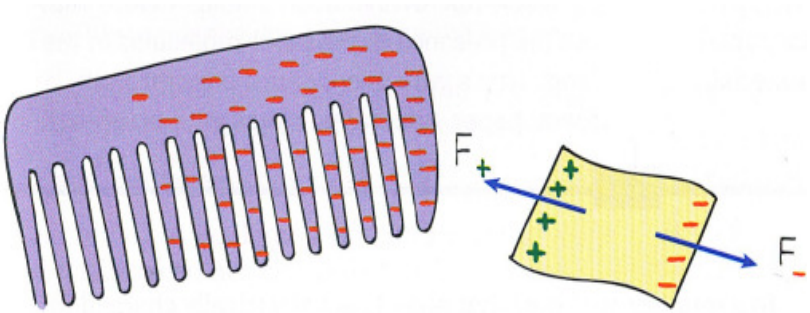
1. Charging by induction occurs during **thunderstorms**

2. Demonstrated by **Benjamin Franklins** kite experiment

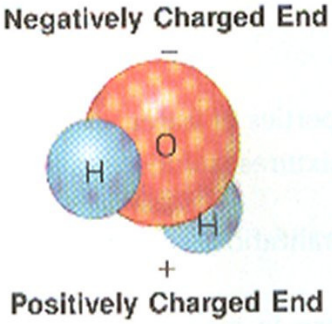
3. Most lightning is an electrical discharge between oppositely charged parts of a cloud.

B. An object can be charged when touched when the charges are separated by induction.

C. **Ground-ing**- when we allow charges to move off (or onto) a



conductor by touching it, it is common to say we are **grounding it.**



1. allow path to practically infinite reservoir for electric charge (the ground)

2. Impor- tant when we talk about electrical cur- rents

3. **Light- ning rod**- designed by Franklin to prevent large buildup of charge that would otherwise lead to a sudden discharge between cloud and building.

VII. Charge Polarization (32.7)

A. When charged rod brought near an insulator, there are no free electrons to migrate throughout the insulating material. Instead there is a **rearrangement** of the positions of charges within the atoms and molecules.

1. One side is **induced** to be slightly more **positive** or **negative** than the opposite side

2. The atom or molecule is said to be **electrically polarized.**