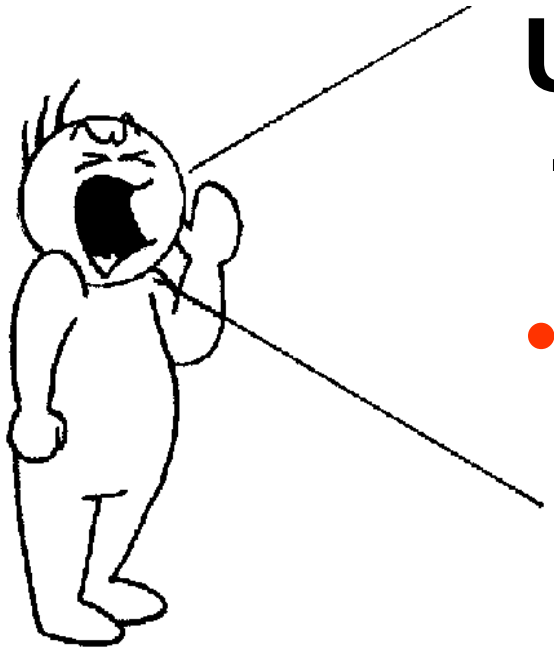
Intermediate Science 9

UNIT 3:

STATIC ELECTRICITY

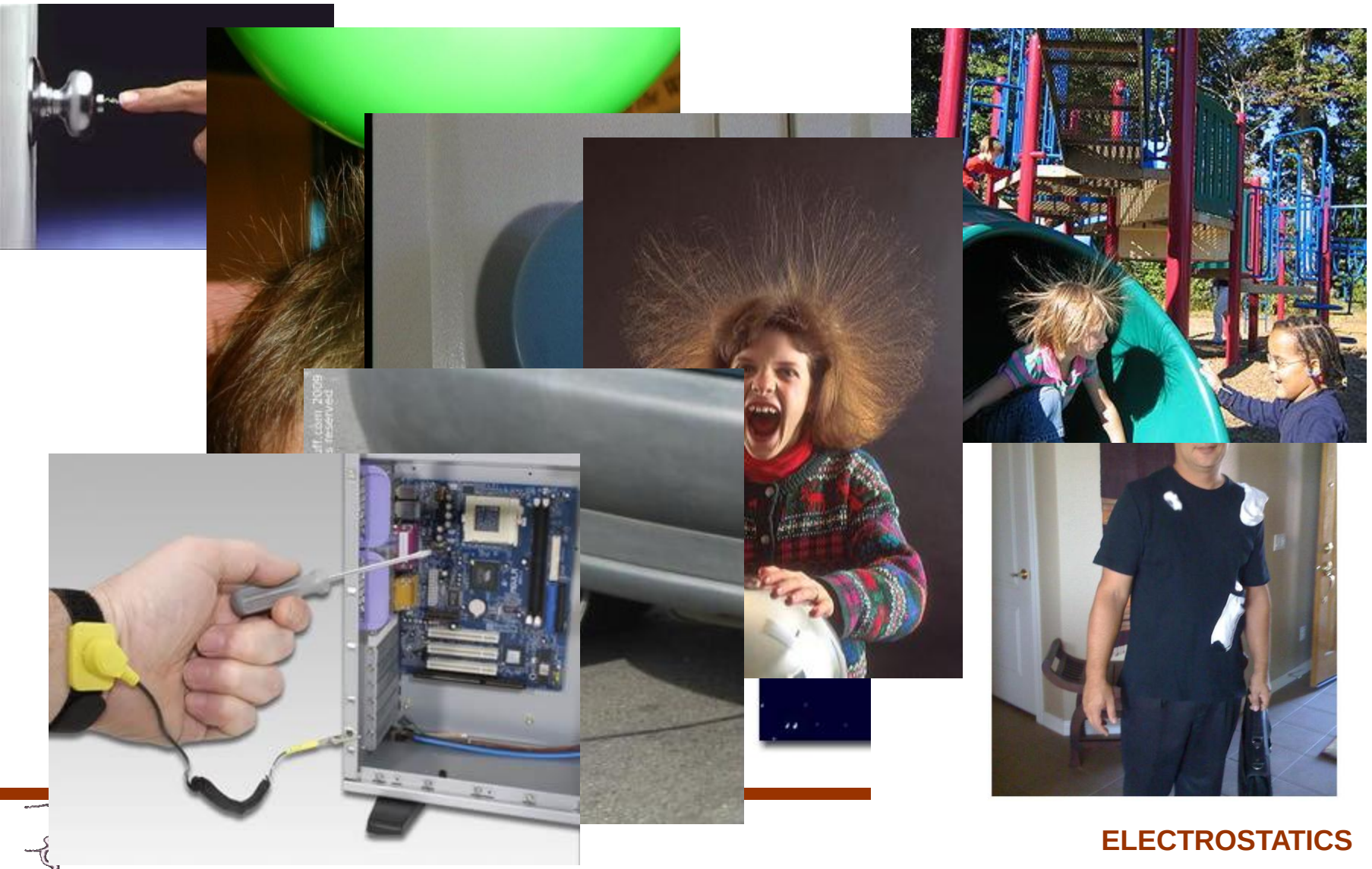


Unit 3

Topic 1

- Electrostatics and the Atomic Theory

There is a large overlap of the world of static electricity and the everyday world which you experience.



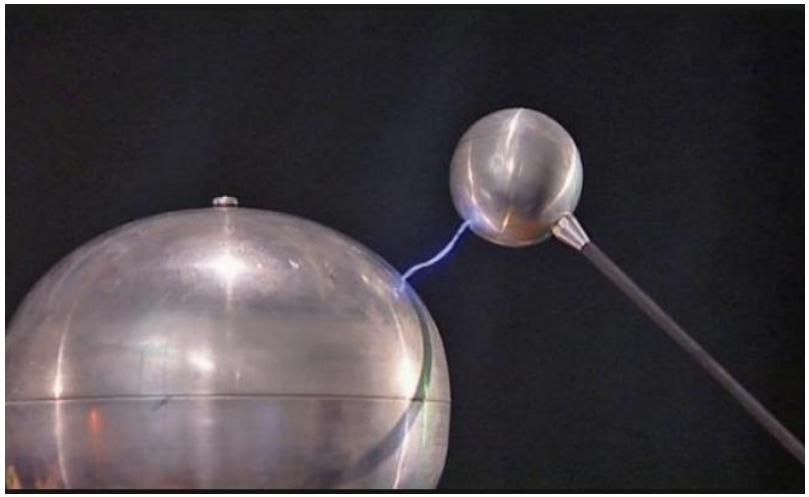
FRANKLIN'S KITE

On June 15, 1752, Benjamin Franklin launched his kite into the dark clouds of a *developing storm. He correctly assumed* that the thunderclouds would have a static charge before there was a lightning strike. His goal was to collect the electricity from these storm clouds. Had lightning actually struck his kite, the precautions that Franklin had put in place would not have been enough to prevent his being electrocuted.

After flying the kite for a few minutes, Franklin brought his knuckles close to the iron key and a spark jumped from the key to his knuckles. This static electricity spark was identical to those produced by friction. Benjamin Franklin had proved that lightning was caused by a build-up of static electricity in the storm clouds.

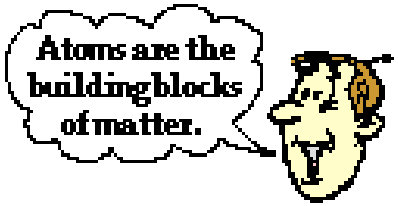
What Is Static Electricity?

Remember Static means at rest.

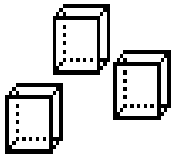
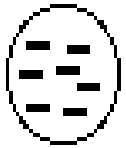
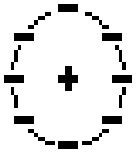
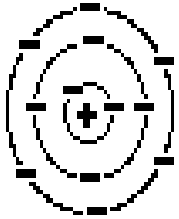
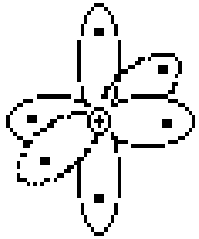


- **Static electricity** refers to stationary electrical charge that is built up on the surface of a material

The interaction between static electric charges is called electrostatics.



Our Changing View of the Atom

"Atomos" are the building blocks of matter.	Negative electrons are embedded in a sea of positive charge.	Positive charge is located within a central nucleus.	Electrons are in circular orbits with quantized energy levels.	Electrons occupy regions of space whose shape is described by complex mathematical equations.
				
Early Greek Philosophers	J.J. Thomson	Ernest Rutherford	Neils Bohr	Quantum Mechanics
400 B.C.	1898 - 1903	1911	1913	Modern Model

Atomic Theory

- Basic Atomic Theory is used to explain electrostatic effects.

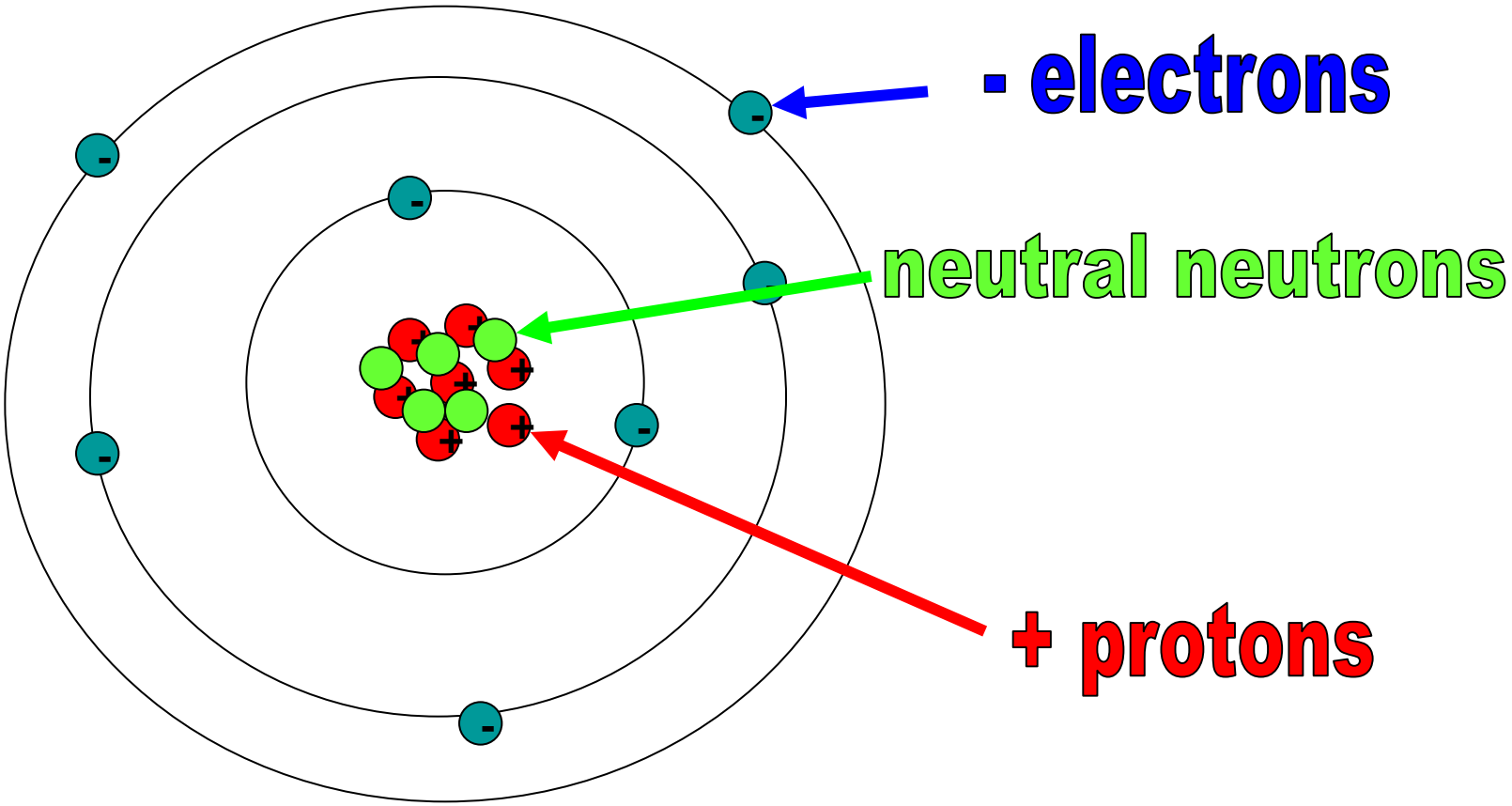
- The Bohr-Rutherford Atomic Model states:

- All matter is made of tiny particles called atoms.
- Atoms can consist of three particles, the electron, proton, and neutron, each having a negative, positive and neutral electric charge, respectively.

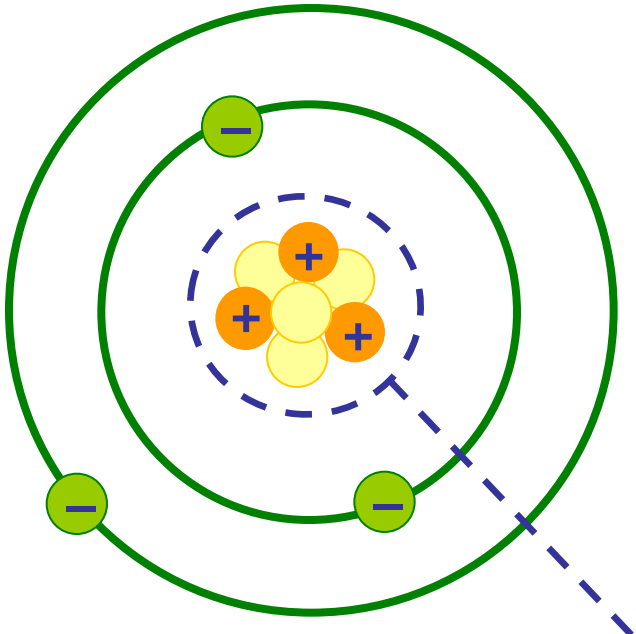
- Protons and neutrons exist in the atomic nucleus, while electrons orbit around the nucleus.

Structure of Matter

- Fundamental building blocks of the matter are atoms.



Matter is made up of atoms.



Proton (positive charge)

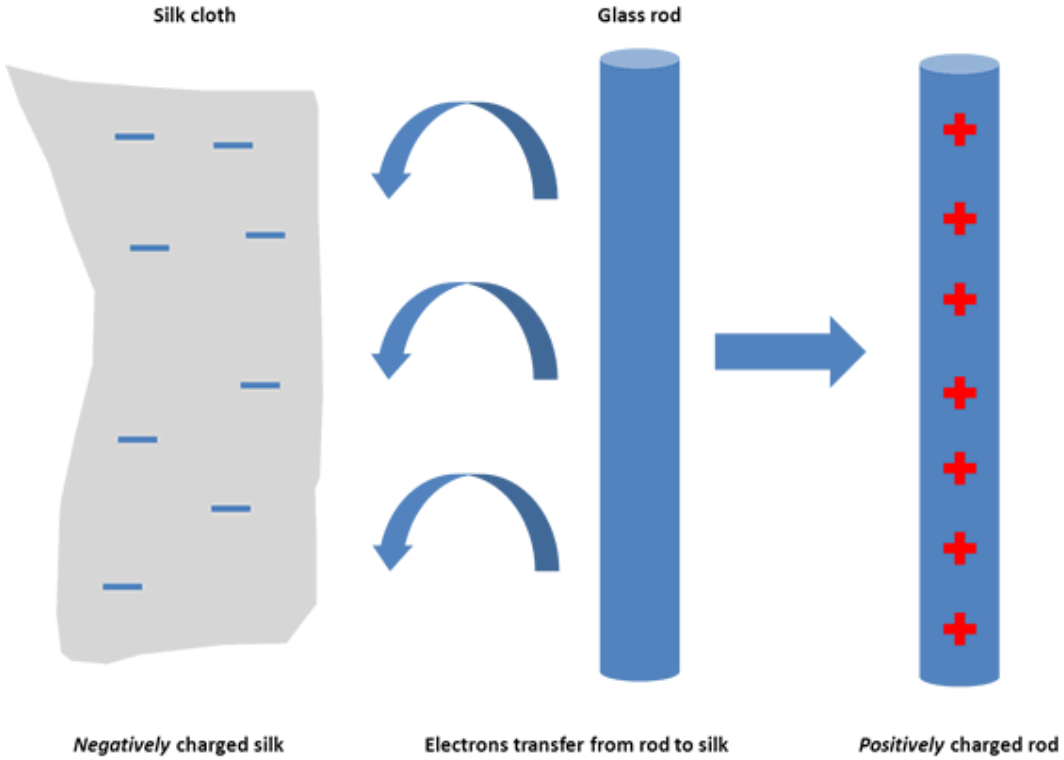
neutron (neutral)

electron (negative charge)

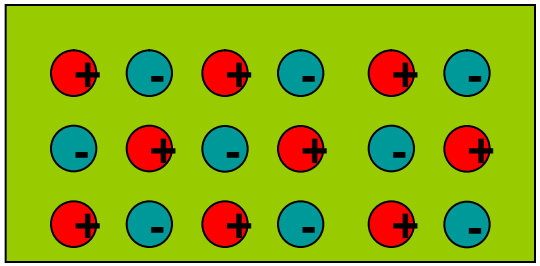
Electrostatic phenomenon can never be explained by the movement of protons and neutrons because they are trapped in the nucleus.

Movement of Electrons

- ***It is the movement of the electrons that is important***

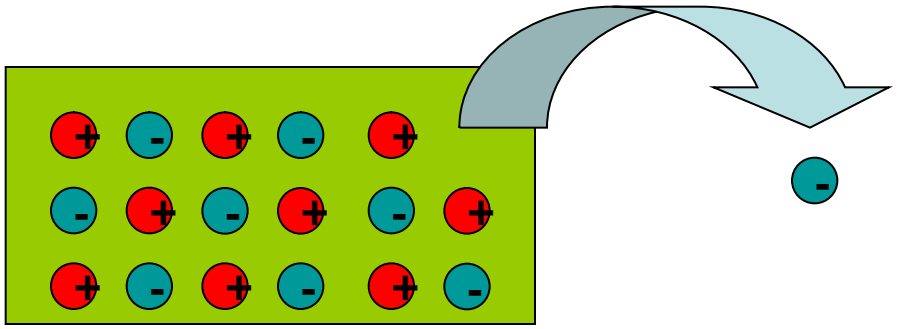


ELECTRICALLY CHARGING OBJECTS



neutral object

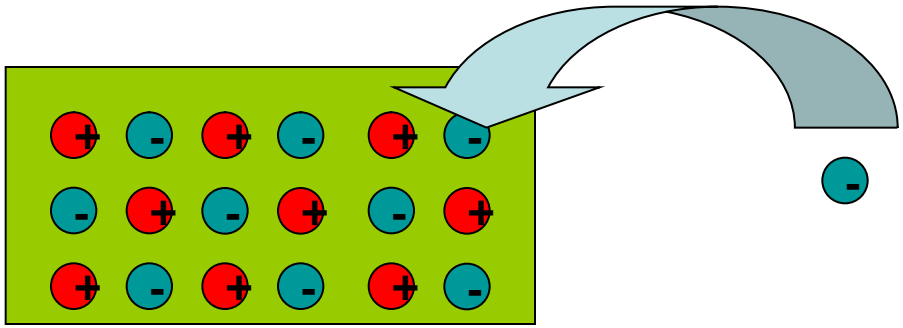
ELECTRICALLY CHARGING OBJECTS



positive object

In order for this to occur, electrons have to leave the object

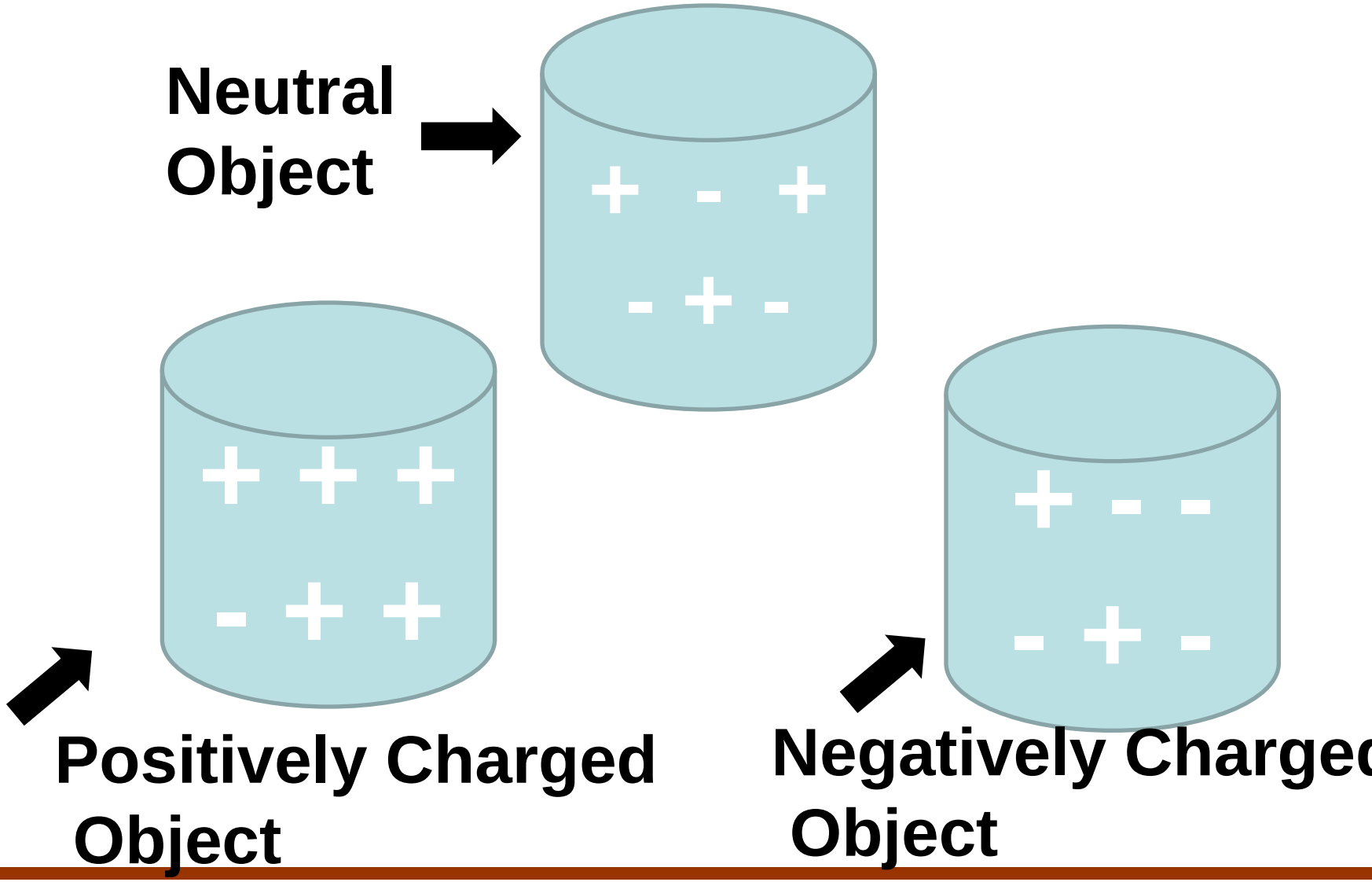
ELECTRICALLY CHARGING OBJECTS



negative object

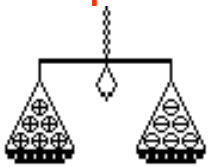
In order for this to occur, electrons have to move on to the object

Charged Objects



Summary Neutral vs. Charged Objects

- electrostatic phenomenon can never be explained by the movement of protons and neutrons because they are trapped in the nucleus. Therefore, it is the movement of the electrons that is important in explaining electrostatic phenomena:



NEUTRAL
NO CHARGE

- **Neutral** refers to having equal number of protons and electrons

- **Charged** refers to having an imbalance of electrons. Two types:

1) **positively charged** having more protons than electrons.

POSITIVE
CHARGE

2) **Negatively charged** having more electrons than protons

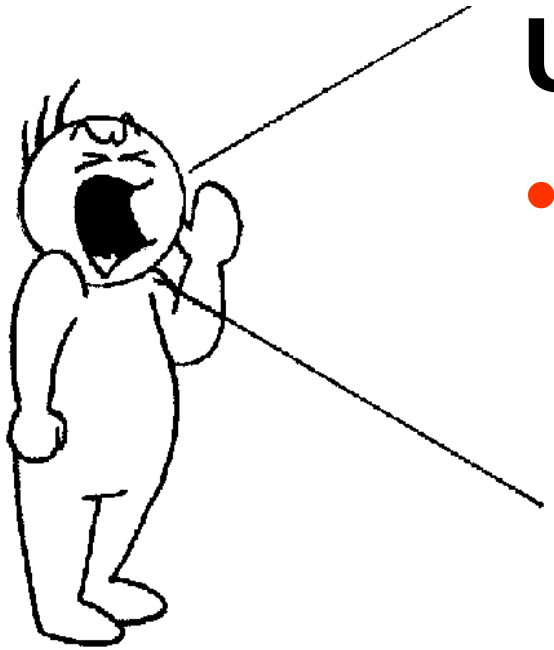
NEGATIVE
CHARGE

STUDENT WORK

- WORKSHEET #1

MOVIE

- Static Electricity



Unit 3 Topic 2

- Laws of Electric Charge


BEWARE OF
STATIC
ELECTRICITY
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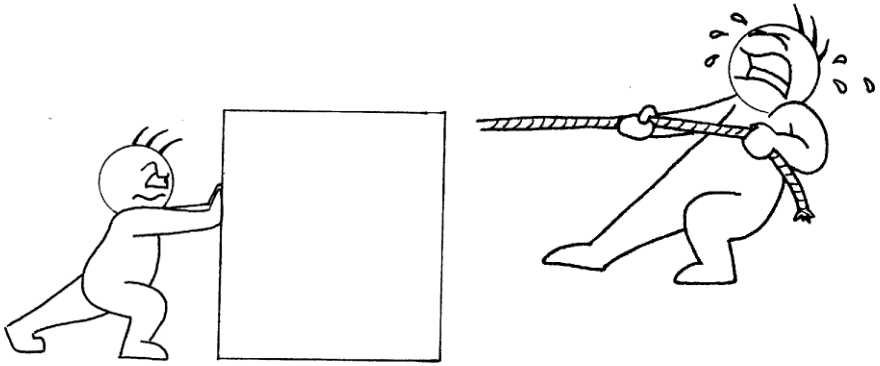
ELECTRIC FORCE

Force is a push or a pull



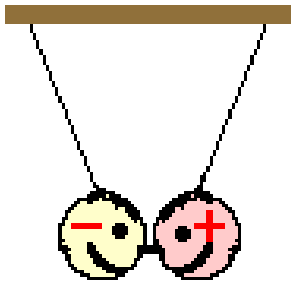
Electric force **is a push or a pull between charged objects**

Action at a distance force **refers to a force that can have an effect without touching**

Law of Electric Charges:

- Observation of electrostatic effects gives the
- **4 Law of Electric Charges**

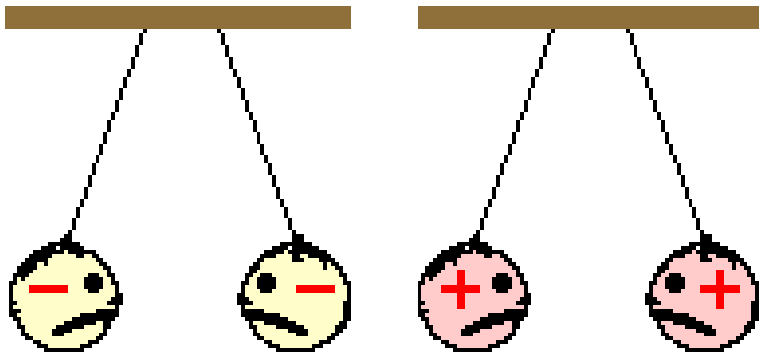
1. Opposite charges attract.



oppositely-charged objects attract

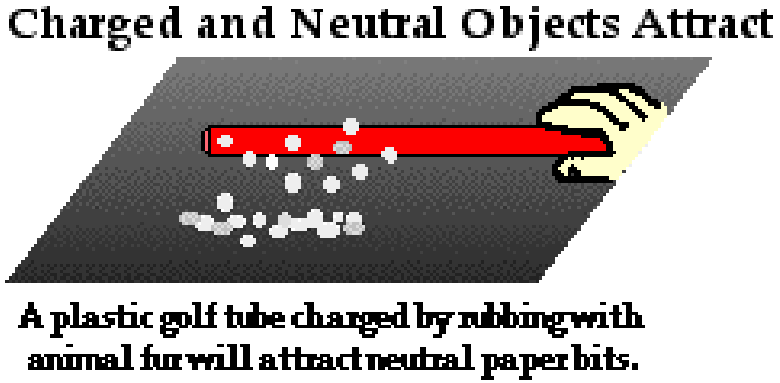
Attractive forces act between opposite charged, pulling them towards each other.

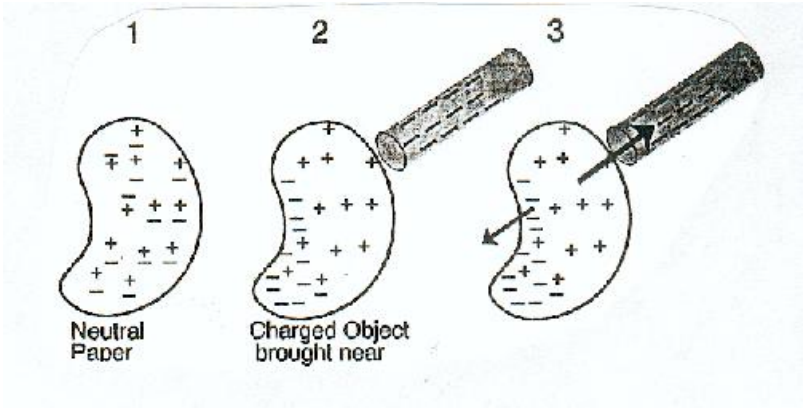
2. Like charges repel.

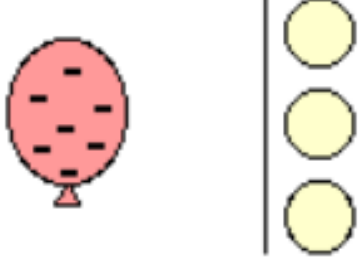


Repulsive forces act between like-charged objects, pushing them away from each other.

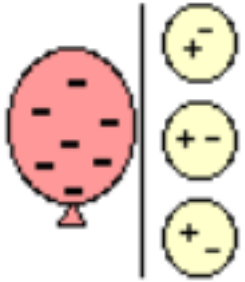
3. Neutral object can be attracted to a charged object







When you rub a balloon in your hair, the balloon becomes negatively charged. Since the balloon is an insulator, the negative charge remains in a nearly fixed location on the balloon



Place the charged balloon against the wall, the negative charges in the wall are repelled away from the balloon. The part of the wall closest to the balloon now has a positive charge because the electrons in that region are repelled. The negative charge on the balloon will be attracted to the positive wall, and therefore the balloon will stick to the wall.

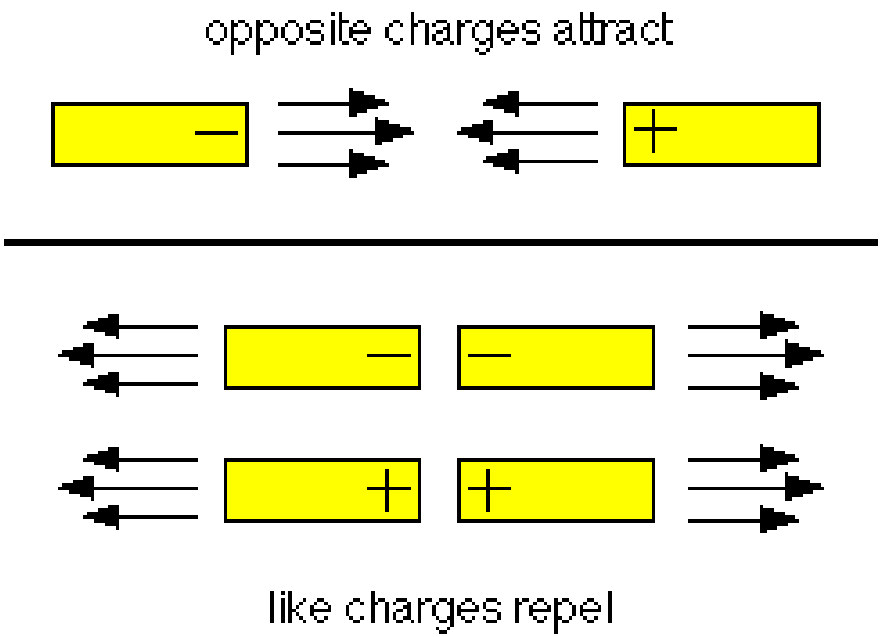
Review Questions

How does a positively charged rod attract a neutral object?

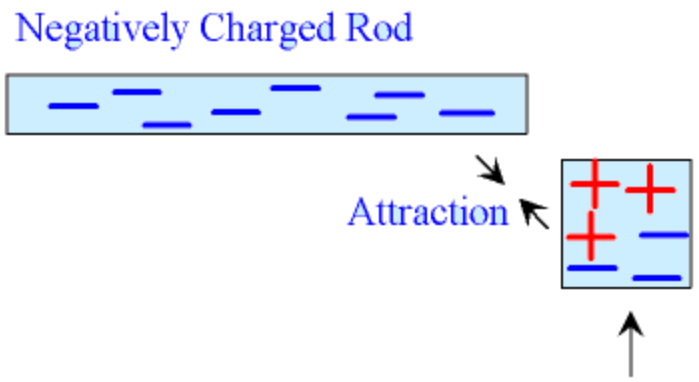
When a + charged rod is put near neutral object, negative charge is induced on the side of the object near the rod and positive charge is induced on the side away from the rod. The rod can attract the netural object because attraction between rod and – induced charge > the repulsion between rod and + induced charge.

Pass out worksheet 2

SUMMARY OF ELCTRIC CHARGE



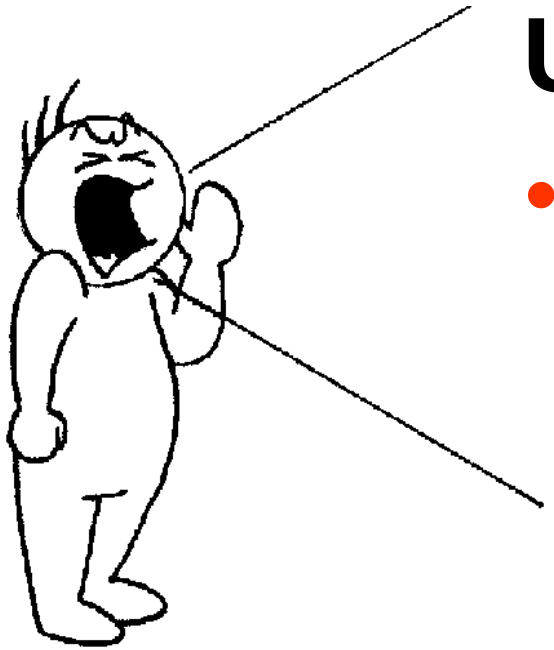
Neutral object can be attracted to a charged object



Neutral object showing electrons repelled, leaving positive charges attracted to the rod.

STUDENT WORK

- WORKSHEET #2



Unit 3 Topic 3

- Measuring and Creating Charge

Late at night, and without permission, Reuben would often enter the nursery and conduct experiments in static electricity.

MEASURING CHARGE

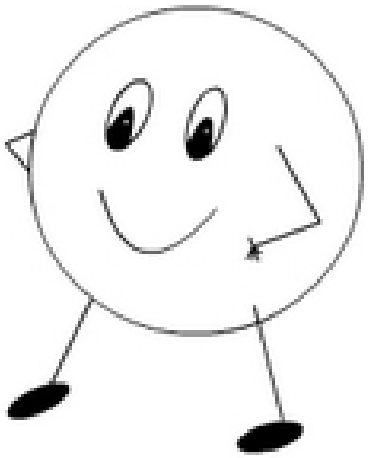
- The unit of electric charge is called the coulomb (C), named after the French physicist Charles Augustin de Coulomb (1736–1806).

1 Coulomb = 6 250 000 000 000 000 000 electrons

or

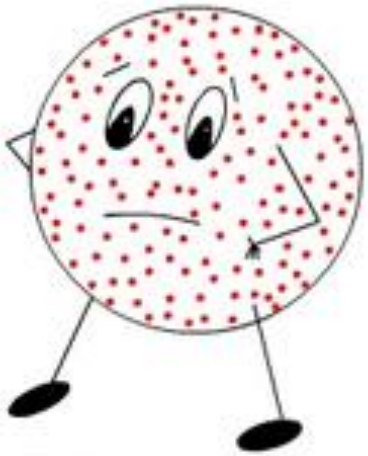
1 coulomb = 6.25×10^{18}

Colin the Coulomb



Colin the Coulomb

Actually Collin the Coulomb is made up of a lot of electrons.

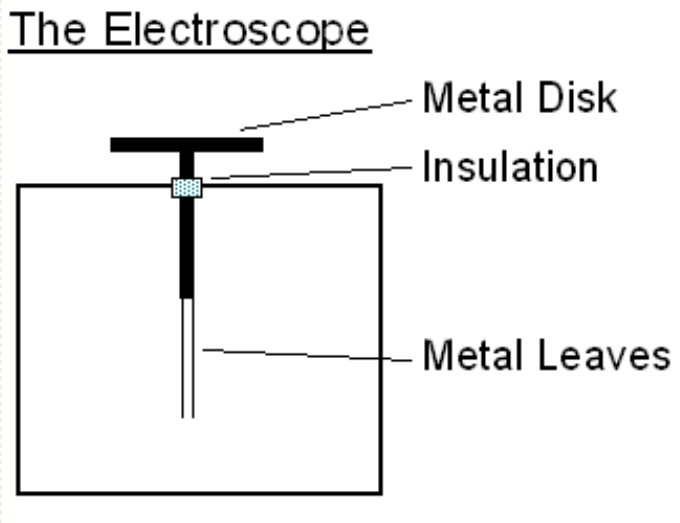


Colin is actually a lot of electrons

1 Coulomb = 6 250 000 000 000 000 000 electrons

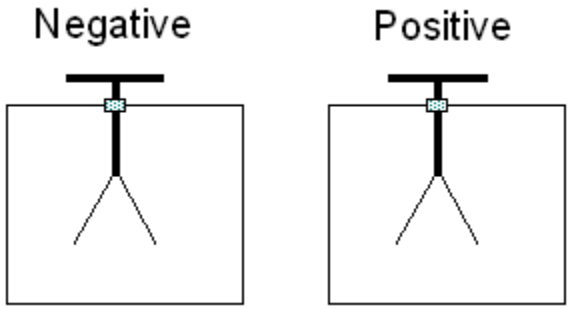
Detecting Charge

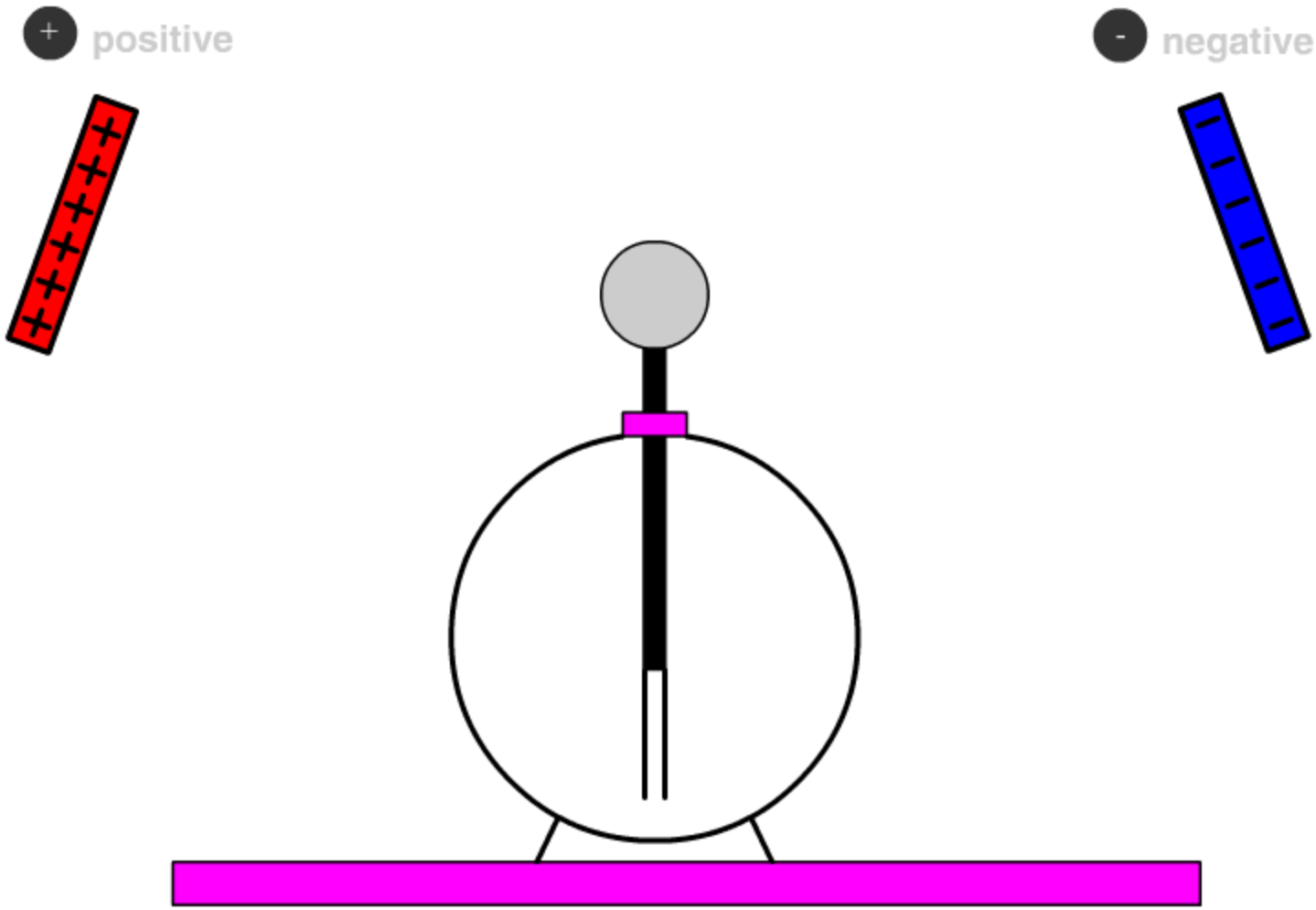
- **An electroscope** is used to detect the presence of a net charge on an object.



- When the electroscope is neutral, the leaves hang vertically.

- When charged, the leaves repel each other and diverge. A larger divergence indicates a larger net charge.




positive
negative

INSULATOR AND CONDUCTOR

- **Insulators:** Materials that do not allow charges to move easily

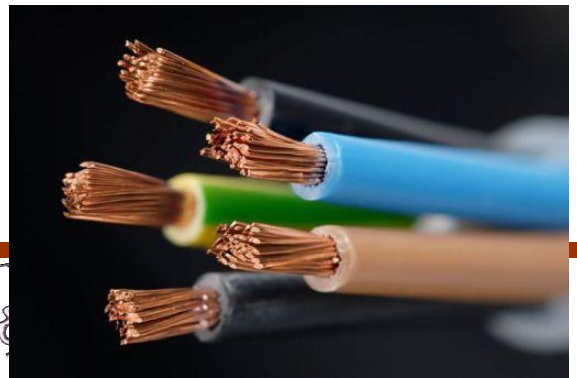
GLASS

PLASTIC

CERAMICS

DRY WOOD

Conductors Materials that allow electrons to travel freely



Examples copper, gold, aluminum

Insulators vs. Conductors:

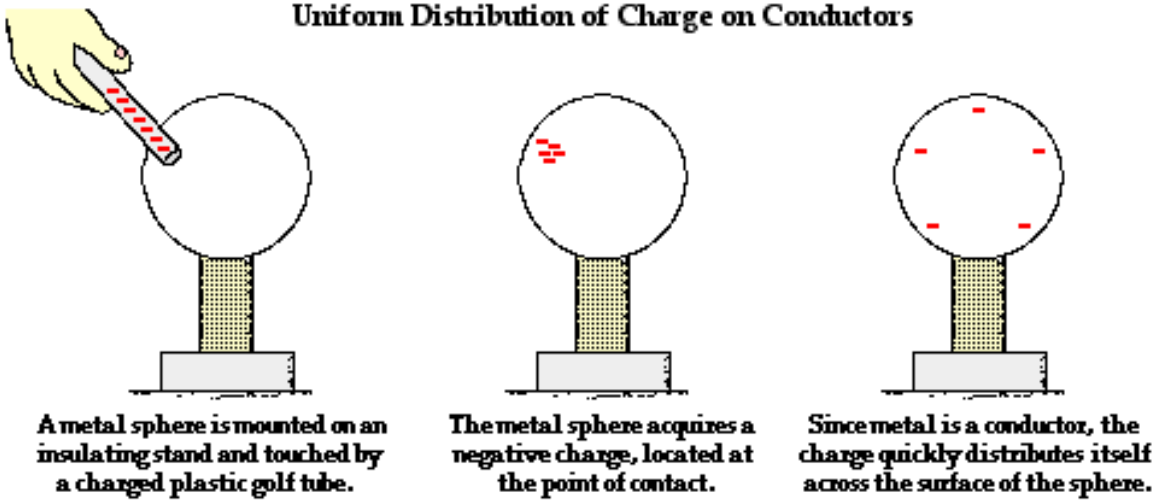
- The movement of charge is limited by the substance the charge is trying to pass through.

A charge on an insulator will stay in one region and will not be distribute. Therefore, only insulators can retain a static charge.

.

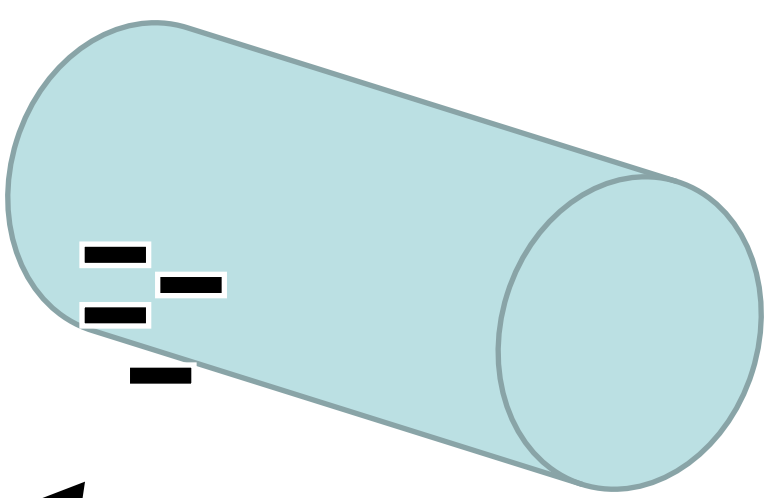
Charged Insulator

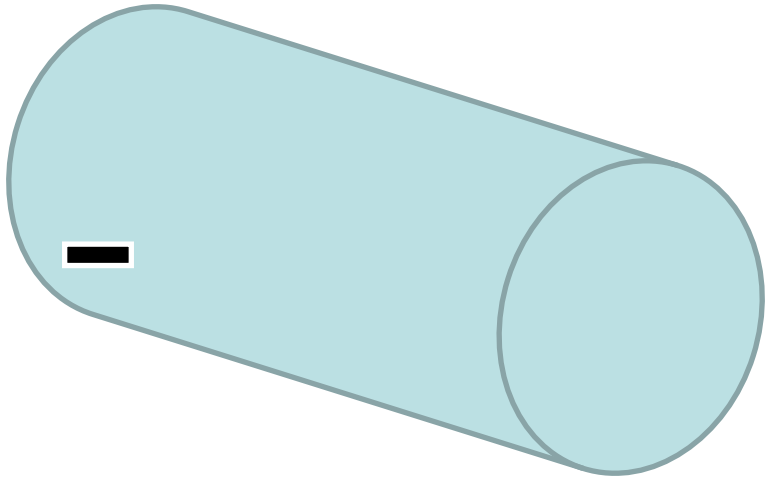
Conductors: allows electrons to flow freely.



Insulators and Conductors

- Insulators don't let electrons flow through them
- Conductors let electrons flow through them

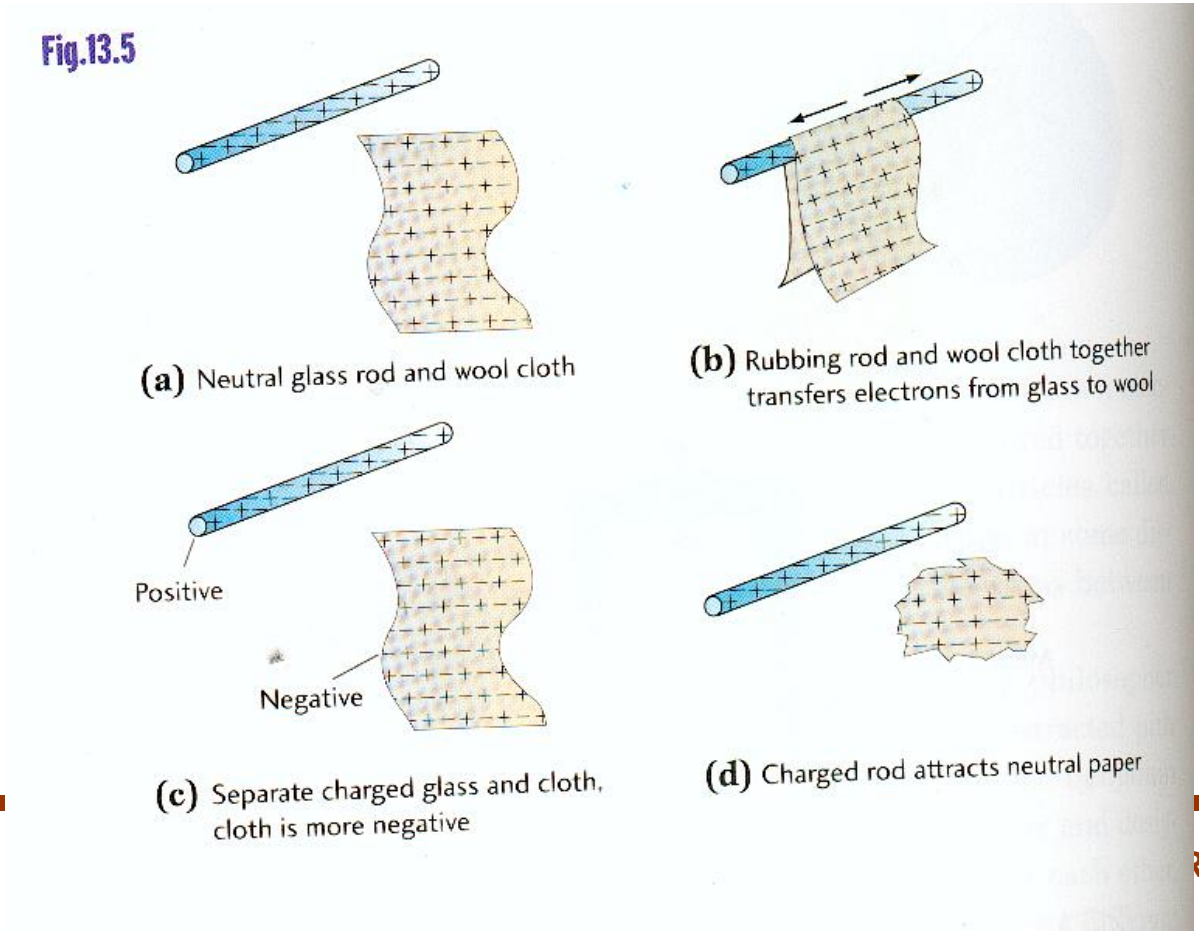




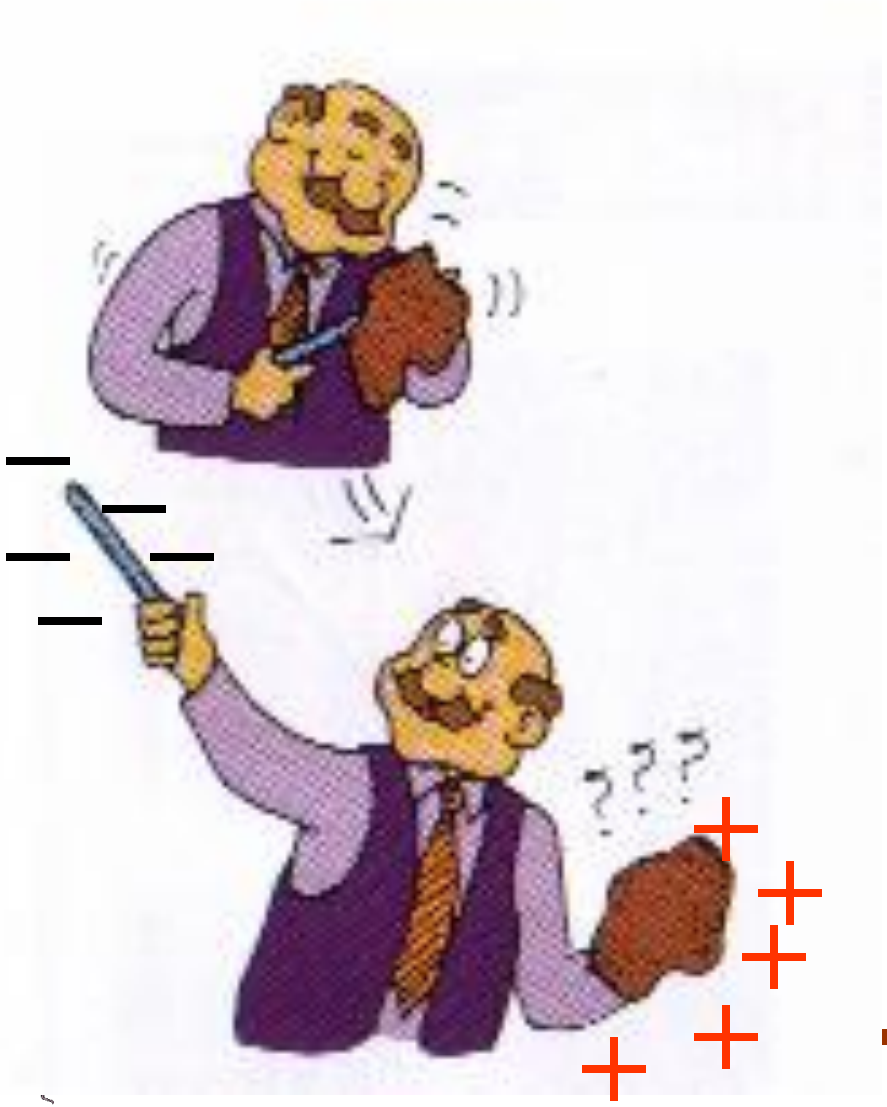
Electrons stay stuck on the surface and don't move—That's STATIC ELECTRICITY!

CHARGING BY FRICTION

- Friction occurs when objects rub against each other. The friction between two objects can result in one object losing electrons and the other object gaining electrons.



Stripping of electrons from one neutral object to another to make two <u>oppositely</u> charged objects

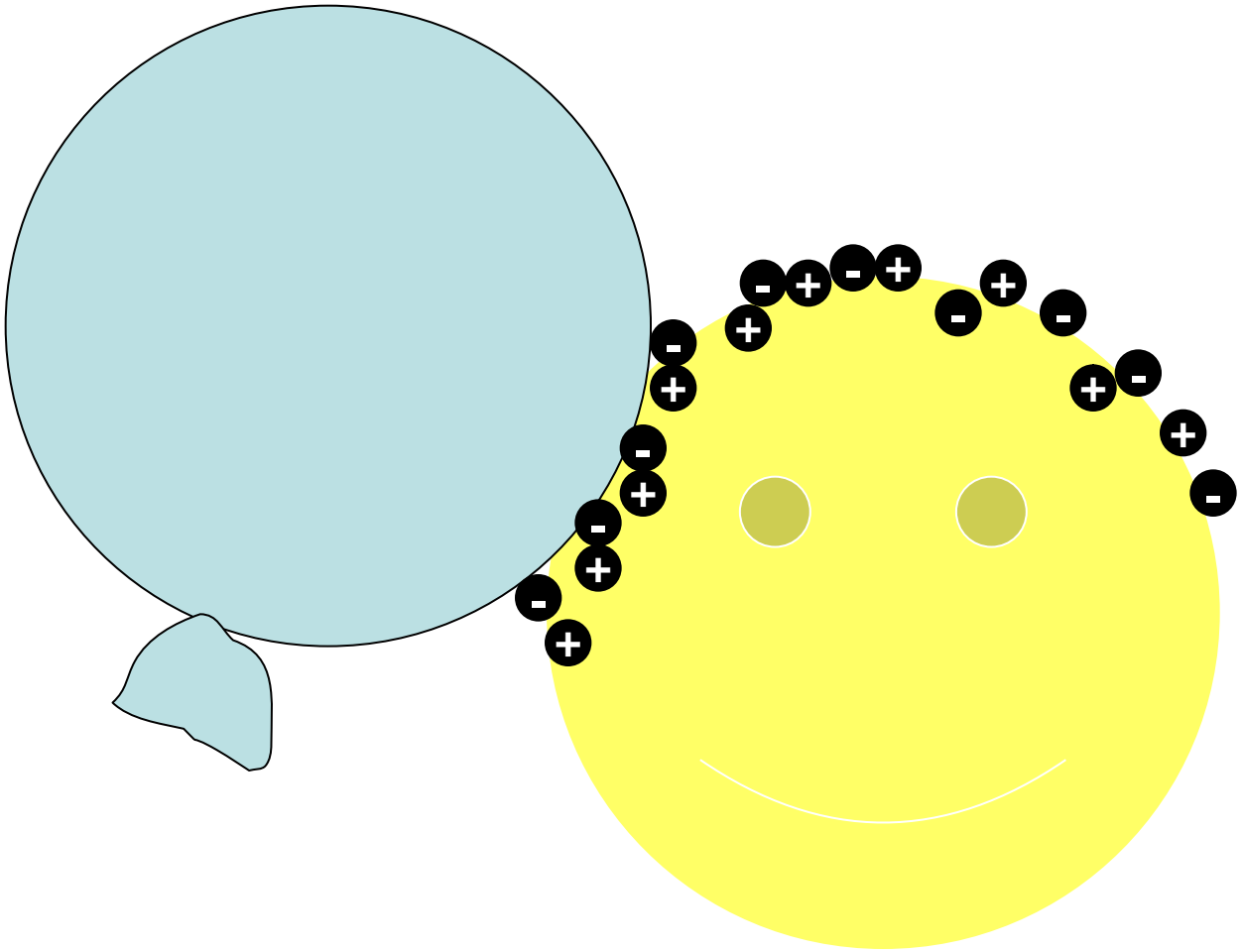


Wool loses electrons to hard rubber rod.

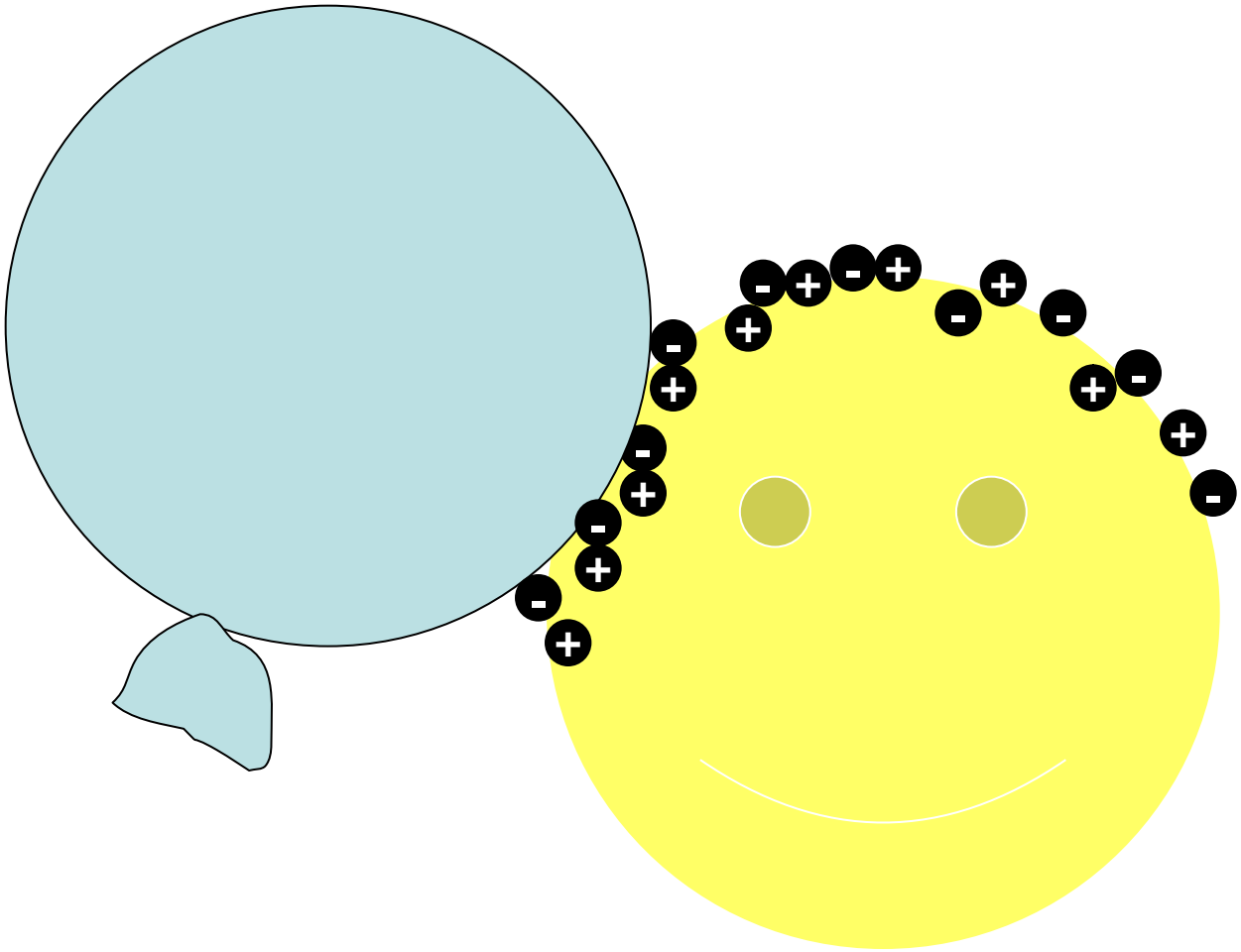
Wool is now positively charged and rod is negatively charged

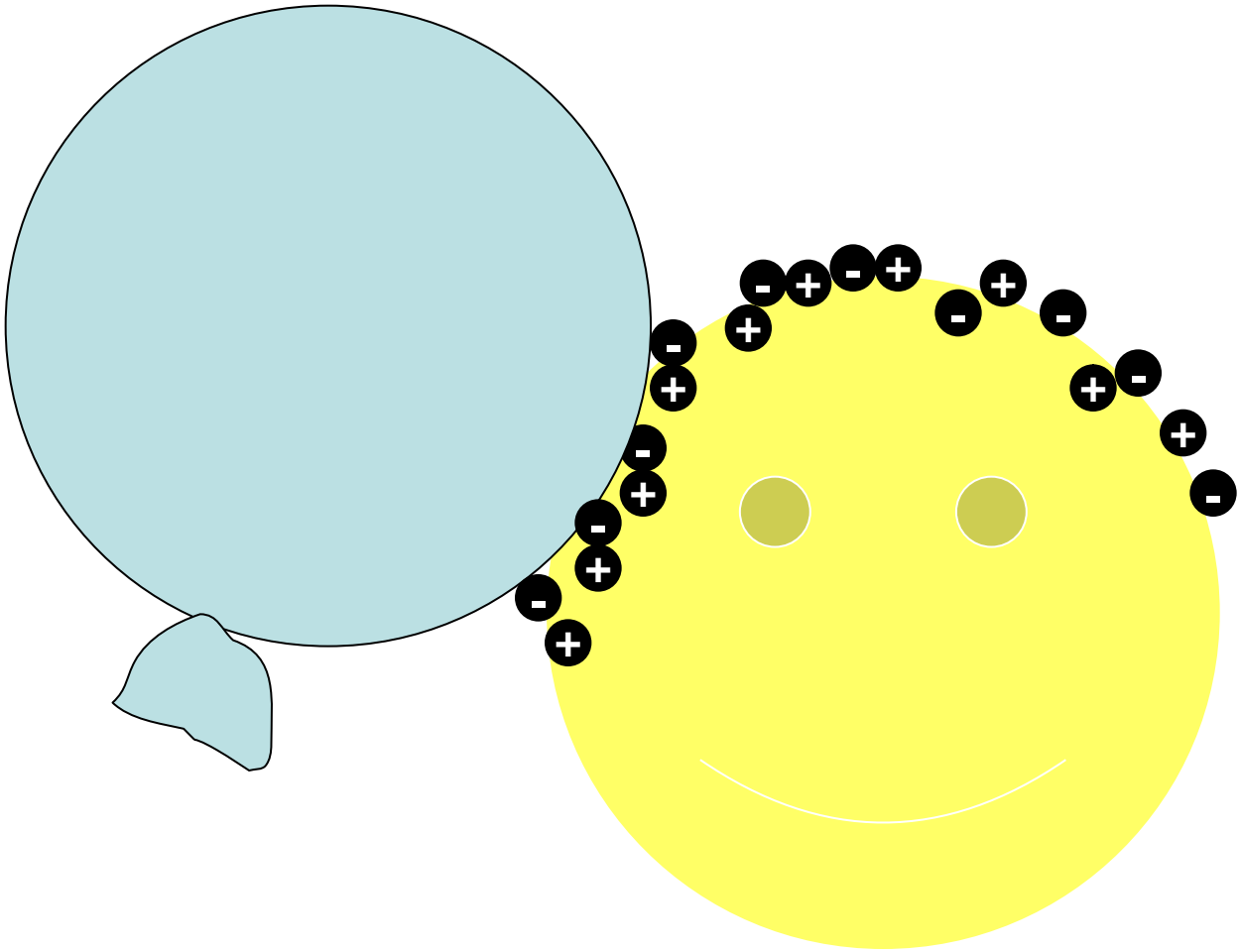
Conductors **CANNOT** be easily charged by friction as the extra electrons gained can easily escape.

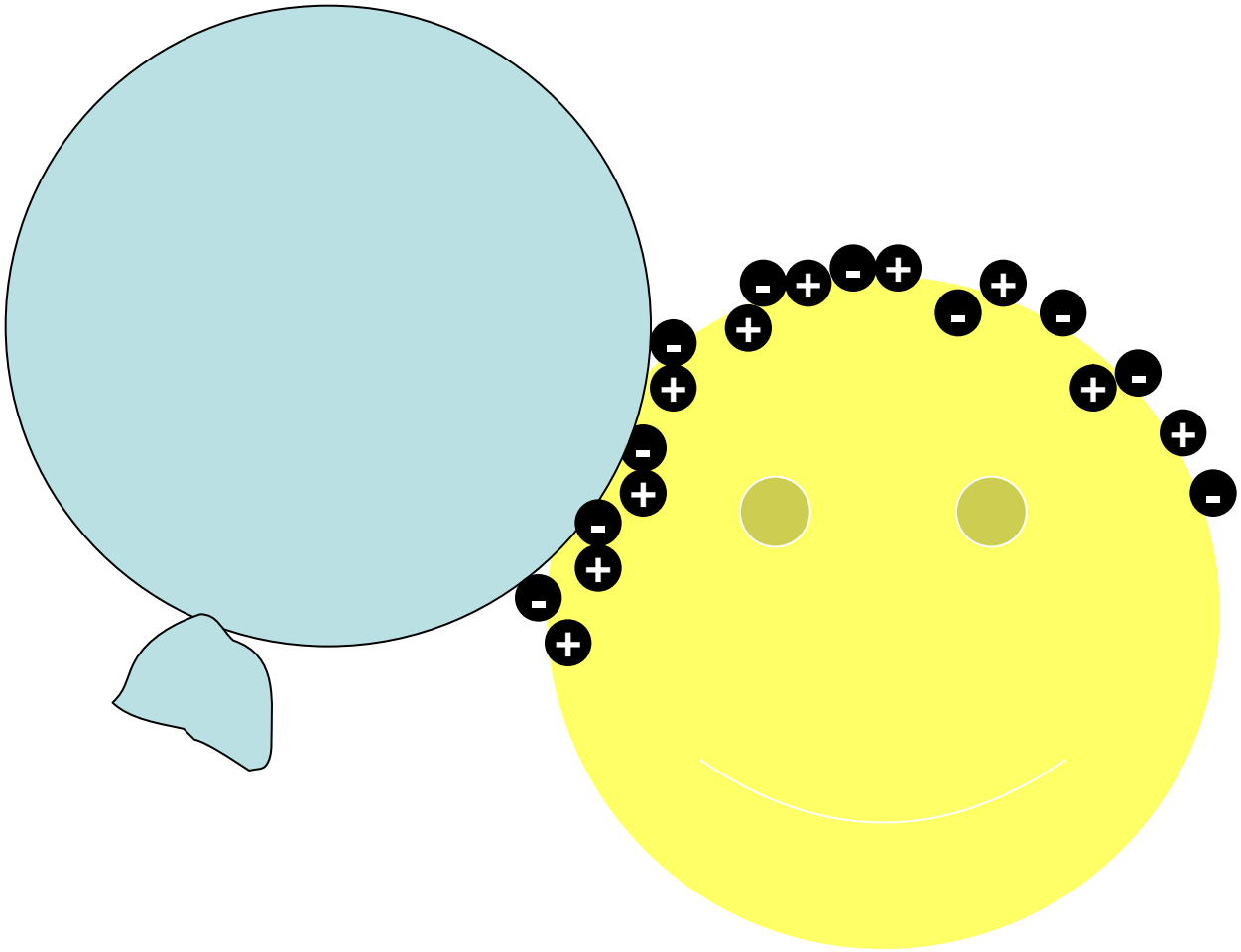
Using Friction to charge a Balloon

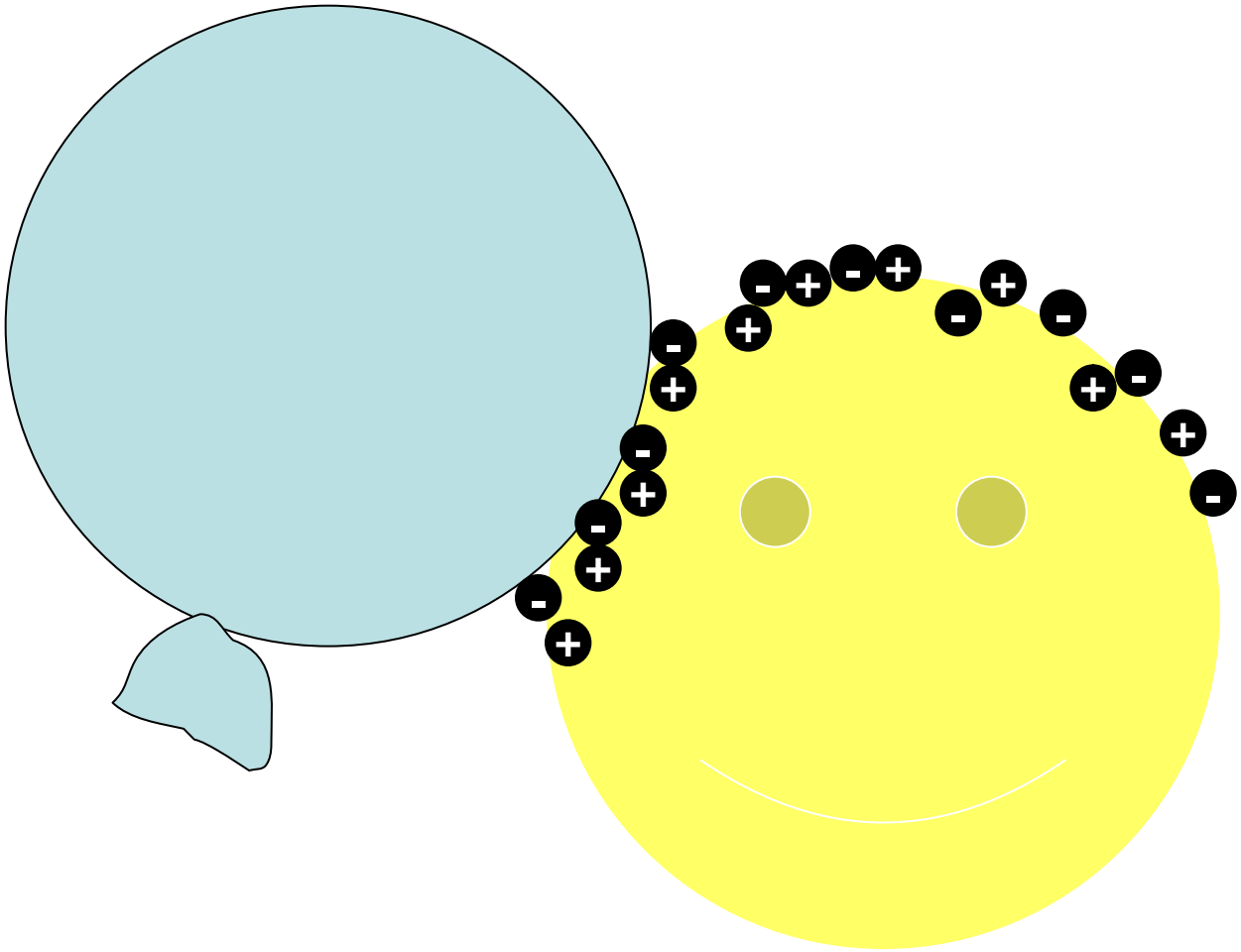


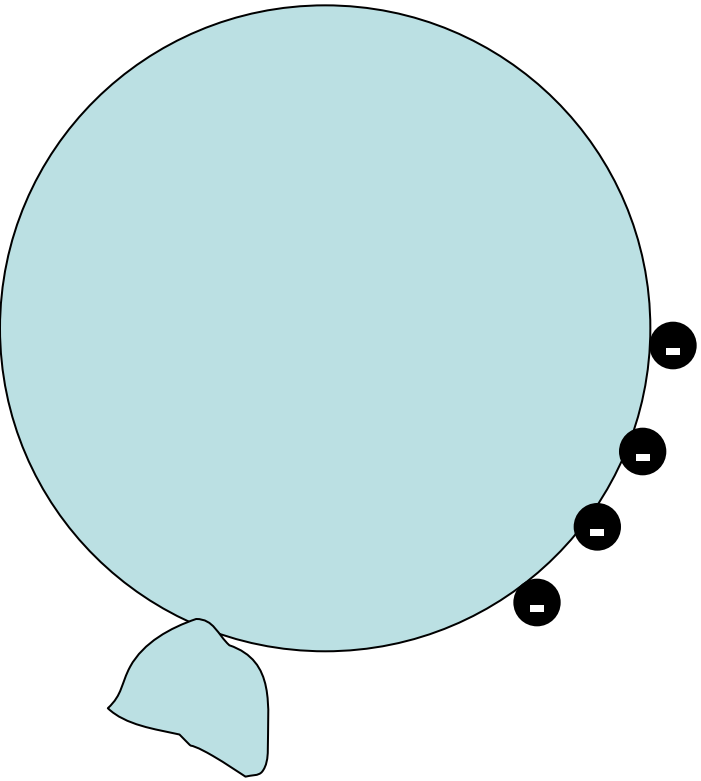
http://phet.colorado.edu/sims/balloons/balloons_en.jnlp

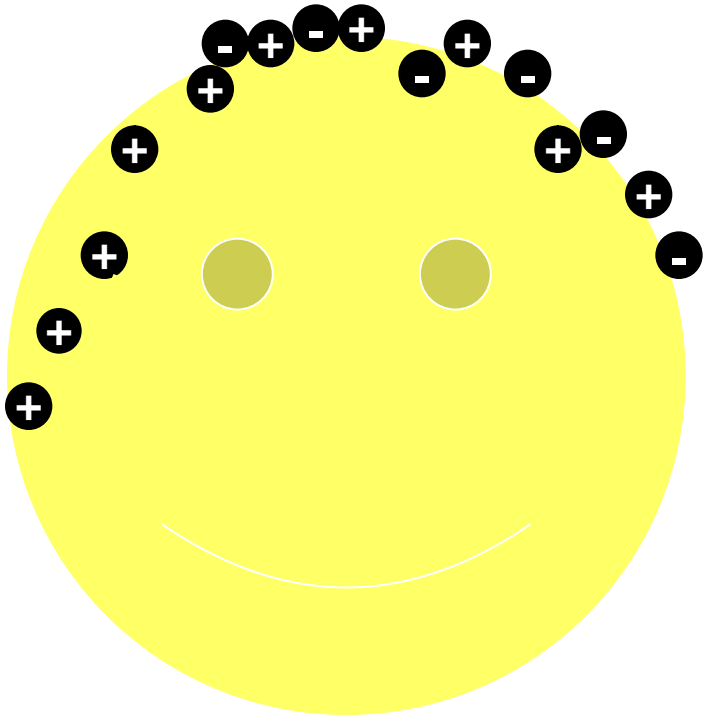












Your shoes on a rug is an example of how static electricity can be produced. As you walk across a rug on a dry day, you gain an electric charge which you are not usually aware of until the electric charge flows from your body (which you experience as slight shock when you touch something). The static electricity is produced because of friction between your shoes and the rug.

Generating Static Charge

- **We have studied how friction can be used to Charge an object.**

The first successful “lightning” machine was invented in 1929 by American physicist Robert Van de Graaff.

The Van de Graaff generator uses friction to produce a large static charge on a metal dome

A moving belt produces a static charge at the base of the generator. The belt carries this charge to the top where it collects on the dome

Review Questions

A balloon has a negative charge when rubbed by a woollen cloth.

1 If the balloon can attract some paper scraps, which of the following cannot be the charge of paper scraps?

A Neutral

B Positive

C Negative

Review Question

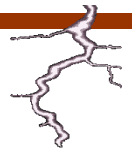
A balloon has a negative charge when rubbed by woollen cloth.

2 During rubbing, what have been transferred between the woollen cloth and the balloon?

A Electrons

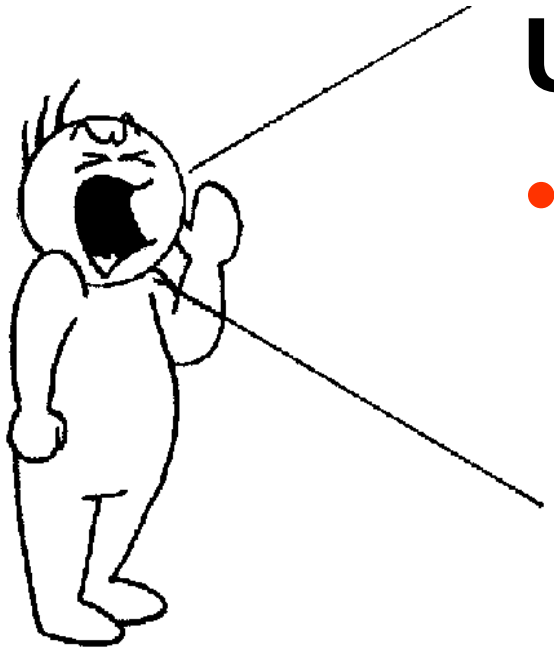
B Protons

C Neutrons



STUDENT WORK

- WORKSHEET #3



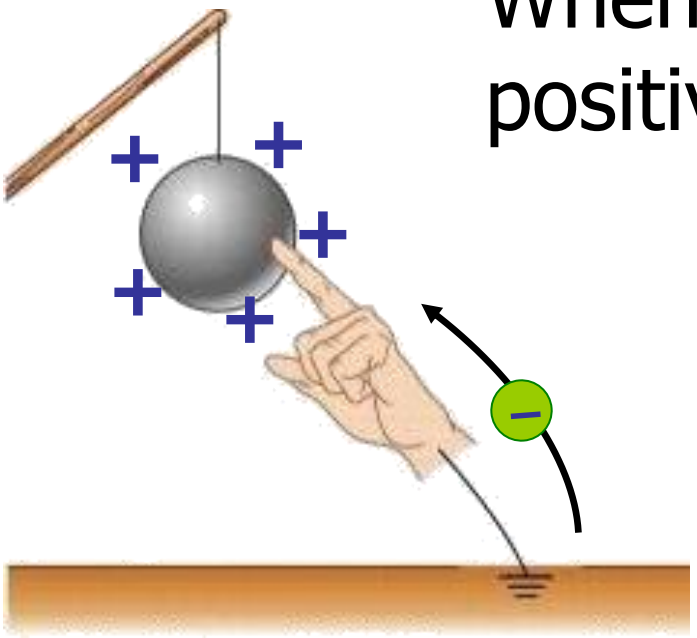
Unit 3 Topic 4

- Grounding and Electric Discharge

Grounding

Ground: **refers to a pathway that allows electric charge to follow. Usually the charge flows to the surface of the earth**

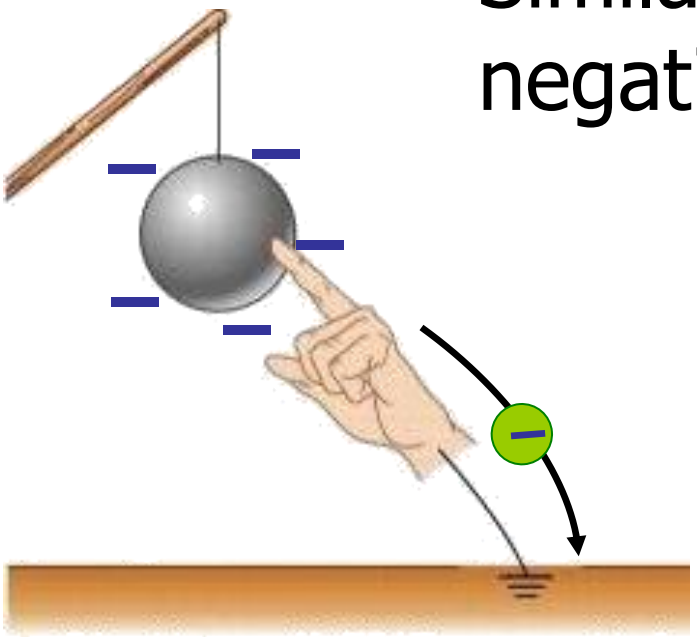
b How does grounding occur?



When we touch a metal ball of positive charge...

electrons flow from the earth to the metal ball to neutralize the metal ball.

Metal ball becomes neutral.

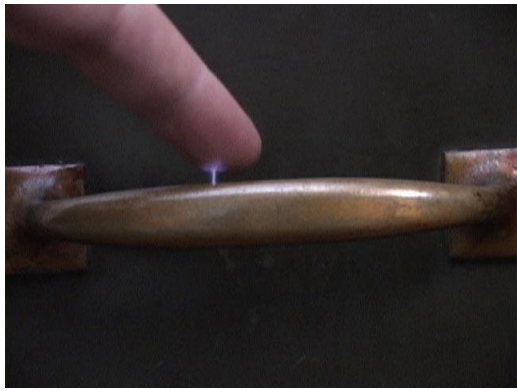


Similarly, if the metal ball is of negative charge...

extra electrons flow from the metal ball to the earth and the ball becomes neutral.

ELECTRICAL DISCHARGE

- **Electric Discharge** refers to the removal of electric charge from an object.



- The discharge is more likely to take place from pointy areas than from flat ones. This is why you are warned to stay away from trees in a thunderstorm.

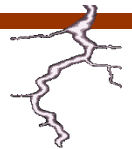
Dangers of Electric Discharge

Trucks that deliver fuel to your local gas station or that refuel airplanes must get rid of all static charge before they begin pumping the fuel . A spark caused by a build-up of static charge could cause an explosion.

EDUCATIONAL VIDEO

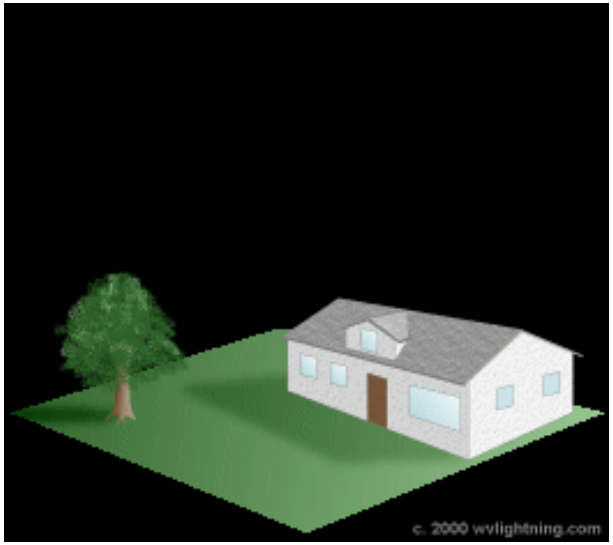
- Fuel Pump Fire (Folder)

Static electrical discharge is indeed a danger while refueling. If a person carries a static charge, a spark that is discharged anywhere near gasoline fumes can generate a fireball and/or explosion.



Lightning

- Lightning is the Granddaddy of electric discharge.

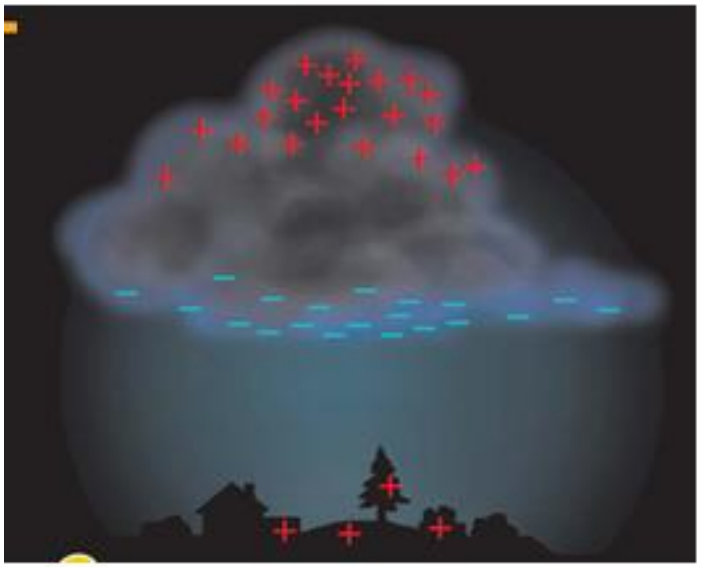


Each year lightning kills approximately 10 Canadians and injures approximately 100 to 150 others

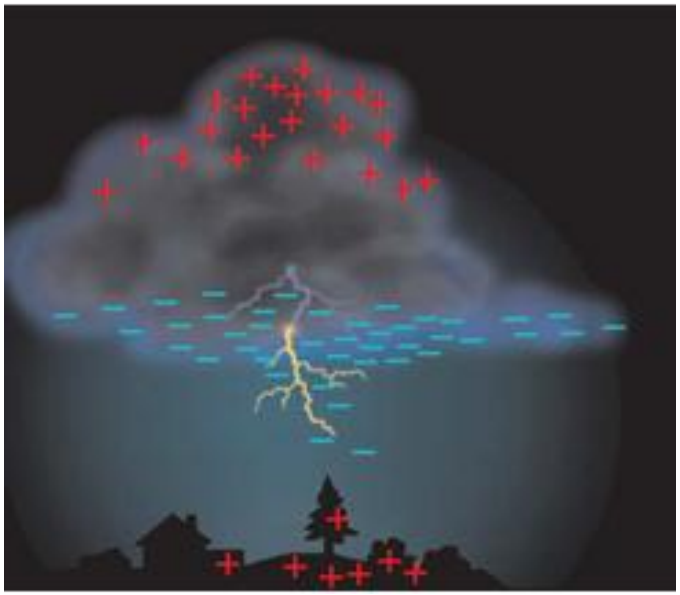
How Lightning works

Convection currents in the storm cloud cause charge separation. The top of the cloud becomes positively charged, the bottom negatively charged.

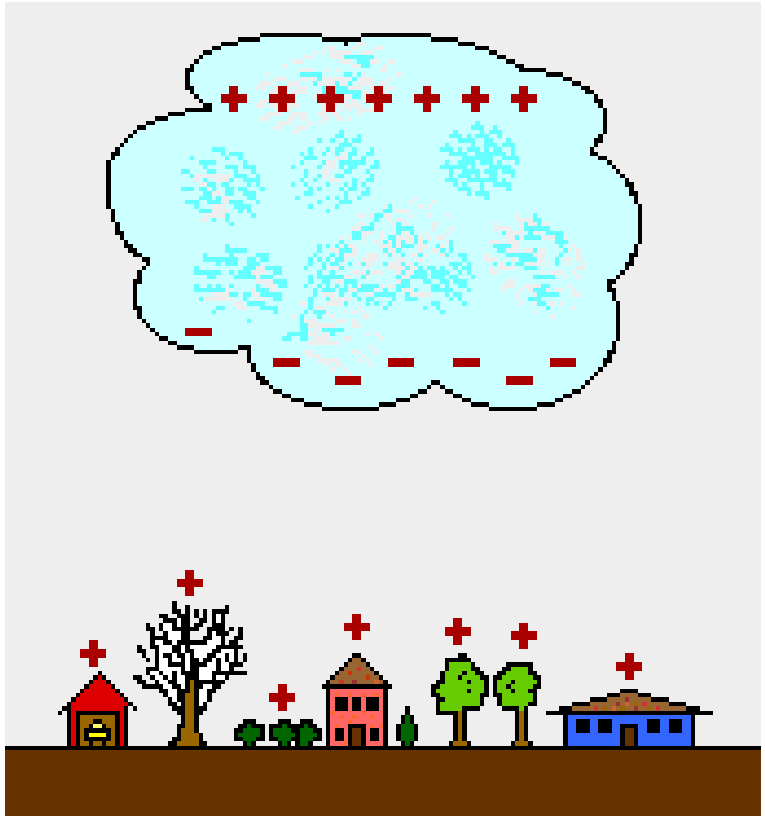
Negative charges on the bottom of the cloud induce a positive charge on the ground below the cloud by repelling negative charges in the ground.



When the bottom of the cloud has accumulated enough negative charges, the attraction of the positive charges below causes electrons in the bottom of the cloud to move toward the ground. This is the spark you see as a lightning flash.



Lightning Movie



Safety In a Lighting Storm

- **If you are inside**

•Stay inside.

•Monitor local radio stations.

•Stay away from windows, doors, fireplaces, radiators, stoves, sinks, bathtubs, plugged-in appliances, metal pipes, telephones and other materials that conduct electricity.

•Unplug radios, televisions and other electrical appliances. Lightning can follow wires leading to electrical equipment.

•Do not go outside to remove laundry from the clothesline as clotheslines can conduct electricity.

•Do not use a phone unless it is a cellular phone.

• If you are outside:

•Take shelter in a building or in a low-lying or depressed area such as a ditch or culvert. Never take shelter under a tree.

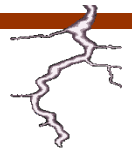
•If you are caught in the open, crouch down with your feet close together and your head down. Do not lie flat on the ground. By minimizing your contact with the ground, your reduce the risk of being electrocuted by a ground charge.

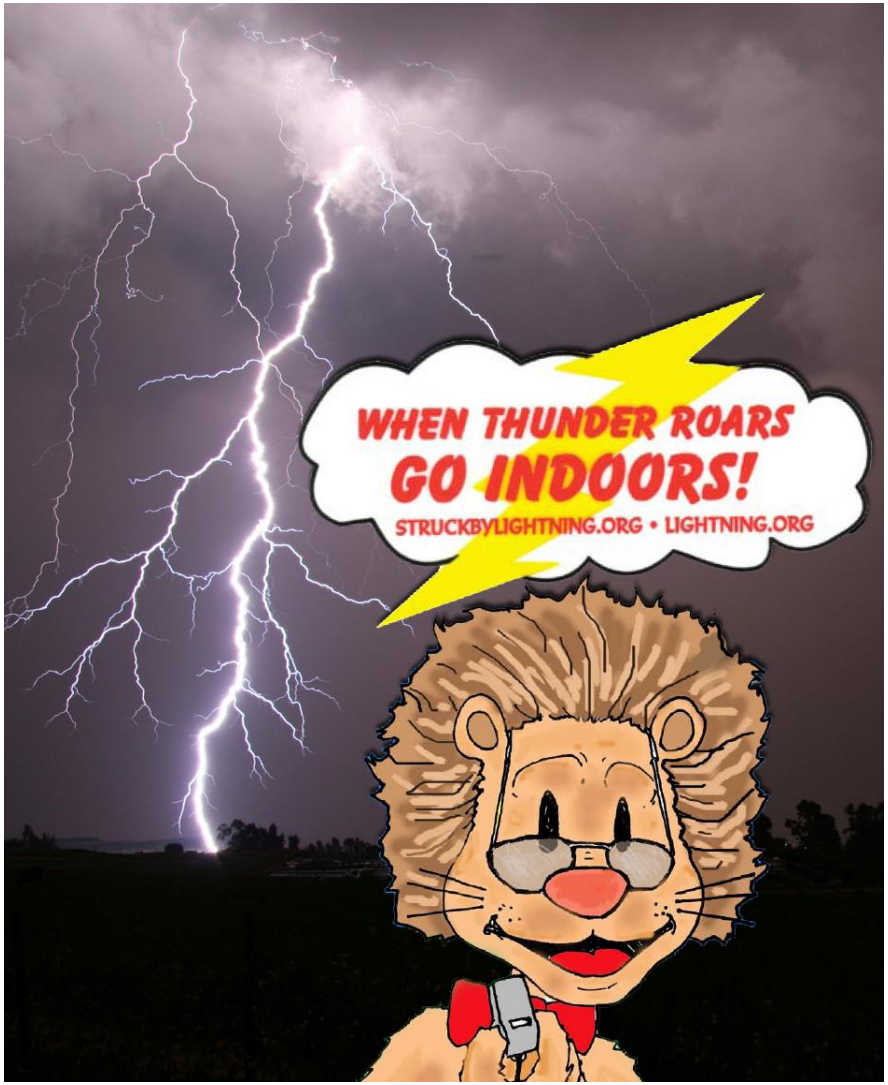
•If swimming or in a boat, get back to shore immediately.

•Keep away from power lines, fences, trees and hilltops.

•Get off bicycles, motorcycles and tractors. Do not use metal shovels or golf clubs. All of these things conduct electricity.

•If you are driving, stop the car and stay in it. Do not stop near trees or power lines as they could fall on you.




WHEN THUNDER ROARS
GO INDOORS!
STRUCKBYLIGHTNING.ORG • LIGHTNING.ORG

Why do gasoline tankers usually have metal chains at the back?

When cars run, their tires and bodies are usually charged by friction. For gasoline tankers, if the accumulated charge is large enough, electrostatic discharge can be produced and explosion will occur if gasoline vapor is ignited. Those metal chains conduct the charge on the bodies of tankers to the ground and avoid the danger.

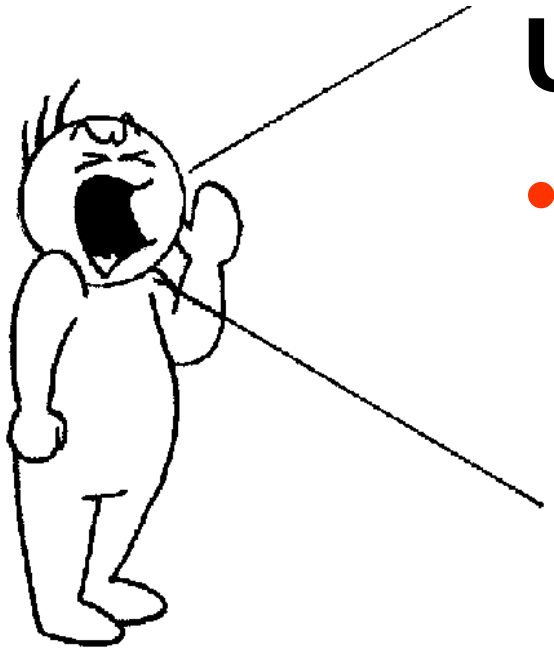
Check out this photo by Ruth Lyon-Bateman from www.lightningsafety.noaa.gov of cows killed by lightning striking the barbed wire fence they were huddled against.

Educational Video

- **Lightning: The Impacts on People (Folder)**

Educational Clip

- Dangers of Static Electricity (Folder)



Unit 3 Topic 5

- Applications of static electricity

Benefits of Electrostatics

1. Lightening Rod

To protect a building from lightning, a lightning rod is placed on top of the building . If lightning occurs near the building, the large amount of charge will pass through the lightning rod to the ground rather than onto the building.

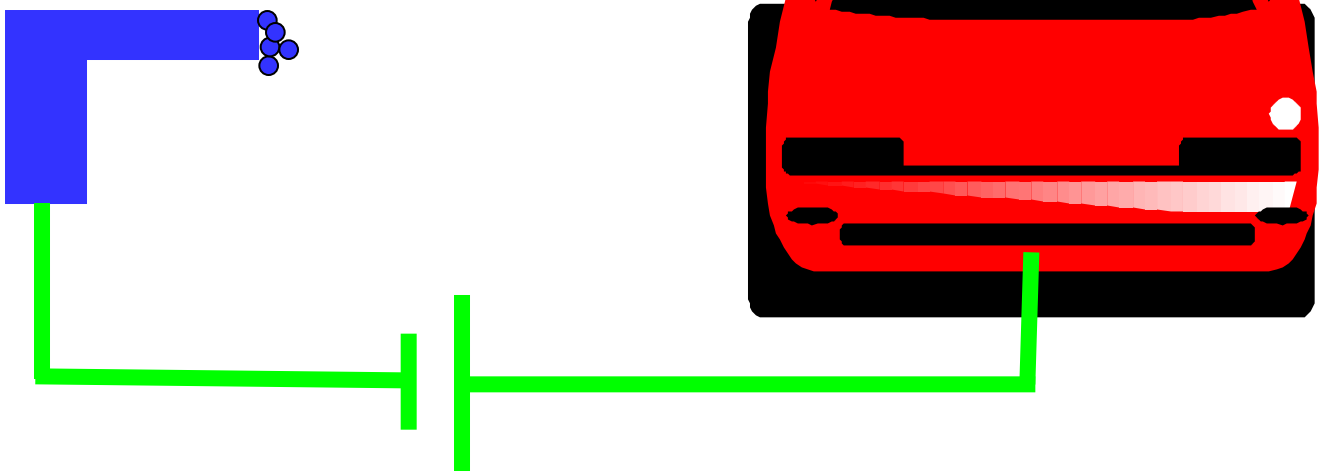
2. Electrostatic Painting

Electrostatic Painting is a manufacturing process that employs charged particles to more efficiently paint a workpiece

Spraying a Car

Positive Car

Negative Spraygun



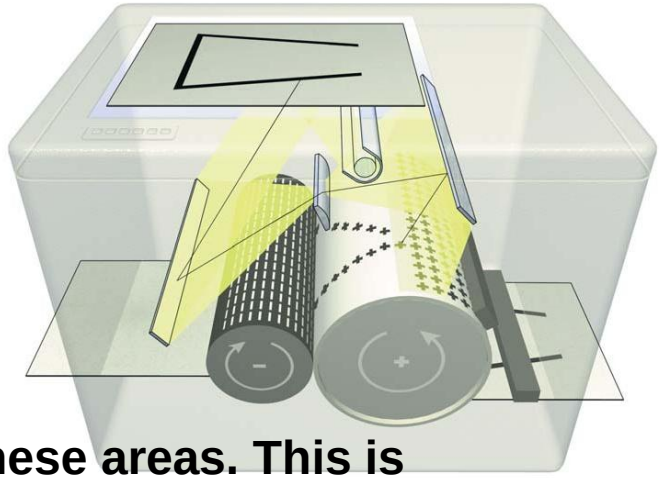
The paint spreads out as each negative drop repels

No paint is wasted as the positive car attracts the negative paint

Educational Movie

Educational Movie “Electrostatic Painting Demonstration” Folder

3. Photocopier



1. Light moves across the document that you place on the copier's glass surface. This light reflects off the white sections of your original and strikes the drum.

2. The charged drum of a photocopier is made of photoconductive material. Where light hits the surface of the photoconductive material, the static charge is removed, so less toner will be attracted to these areas. This is now a copy—in static electricity—of your original.

3. The machine then spreads the neutral toner over the surface of the drum. The toner sticks only where the drum has a static charge.

4. A positively charged blank sheet of paper passes over the surface of the drum. This sheet of paper has a larger charge than the drum. The toner is pulled off the drum and onto the paper by the large positive charge.

5. The toner is then baked onto the paper with heat as soon as the page comes off the drum. Finally, an exact copy of your original is ejected from the photocopier.

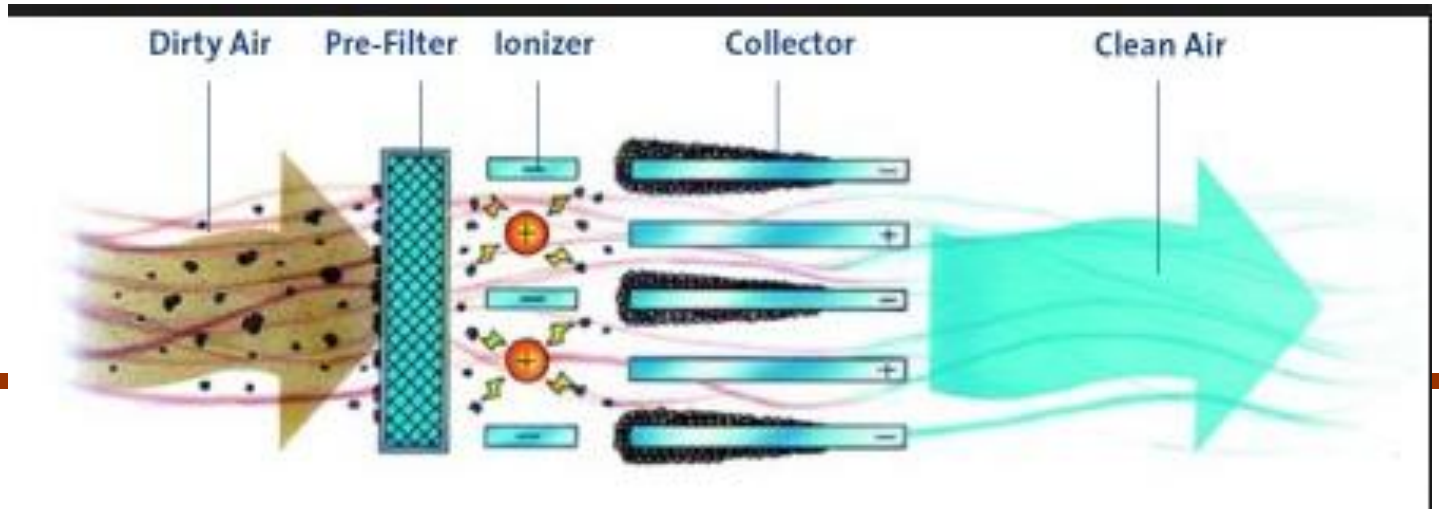
Educational Movie

Educational Movie “How Photocopiers Work” Folder

4. Electrostatic Air Cleaners

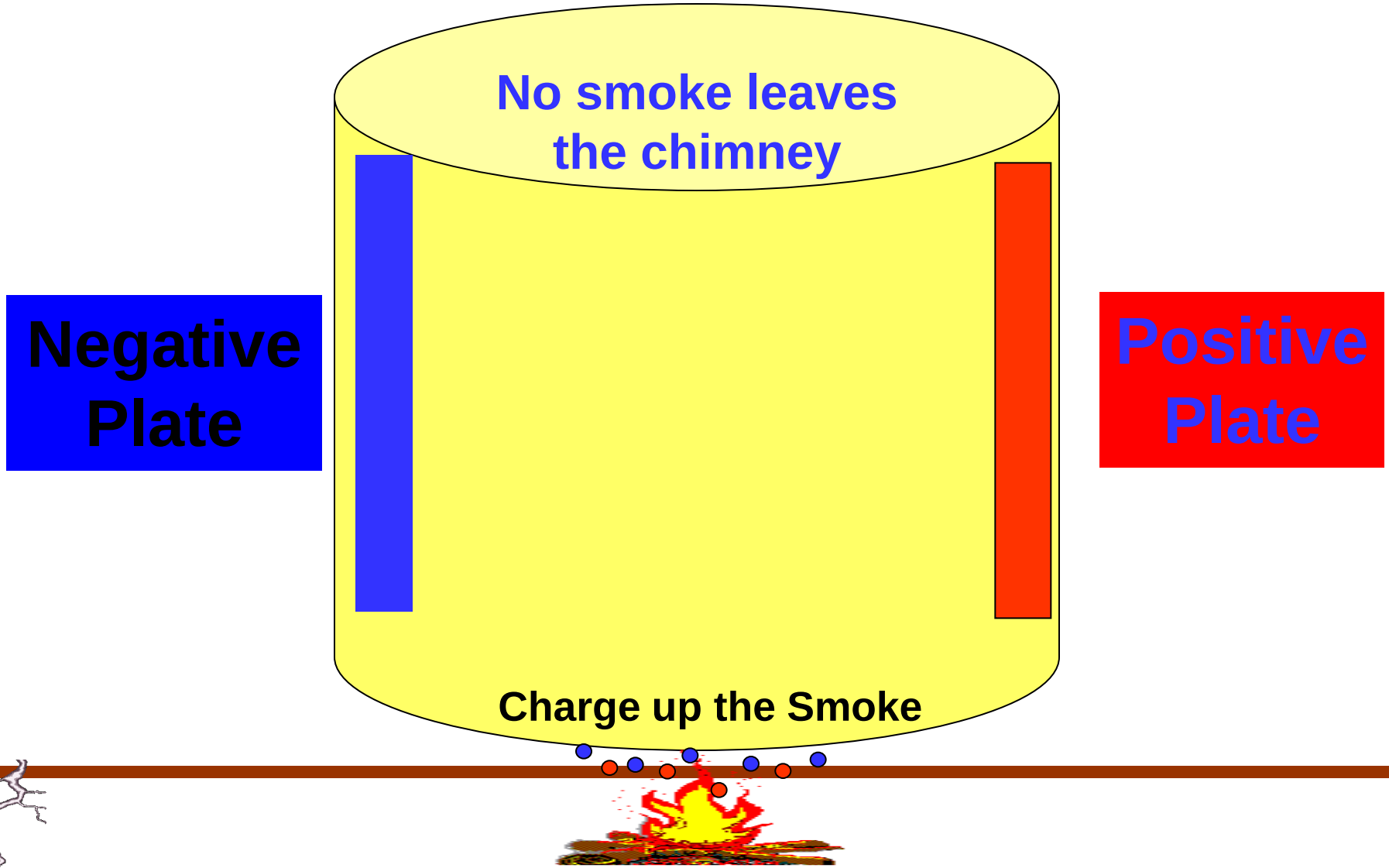
- **Air ionizers that freshen the air inside homes work in a similar way.**

- **The ionizers remove electrons from particles in the air, and the charged particles are then attracted to a plate on the device.**

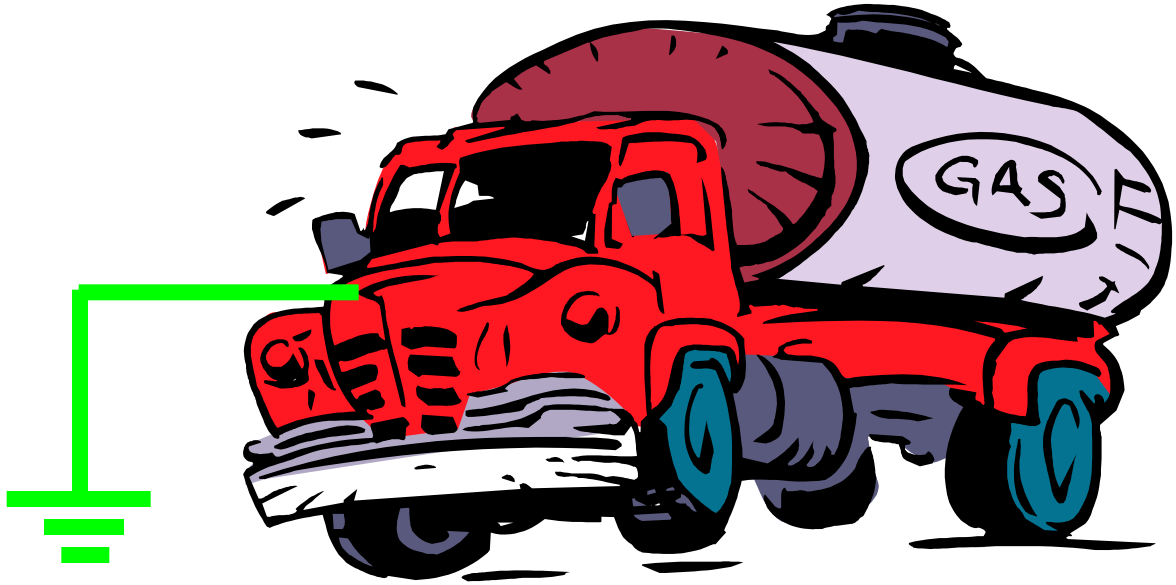


5. Electrostatic Precipitator

Removing Smoke from Power Station Chimneys



6. Ground Placed on Vehicles



- Petrol rubbing against the pipe can build up a static charge which could cause an explosion

The tanker is joined to the ground with a wire to stop a charge building up

Student Activity

- Create a For Sale Sign for some “Application of Static Electricity”

Your Poster should include:

- **Name of what you are selling:**
- **How is works**
- **Pictures/Drawing**
- **Price**
- **Phone number**