Name: ____________________

Period: ____________________

Charge and Electricity

Electric Charge

Charge is a fundamental property of matter, like mass. Objects are either positive, negative, or neutral.

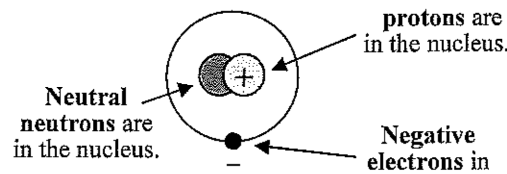
Electric charges works like magnetic poles:

Like charges repel **Opposites attract**

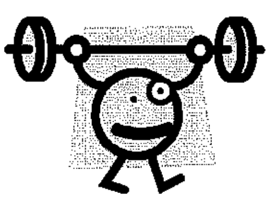
Charges can only move because of electrical forces.

The unit of electric charge is the coulomb.

Charges come from within the atom



Hydrogen Atom
(1 proton)

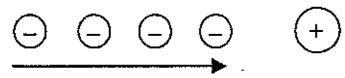


Electrical forces are very strong! If 1 negative coulomb were 1 meter away from 1 positive coulomb the force would be 9 billion newtons! Yes, **9,000,000,000** N! This is how strong the forces are that hold molecules (and you) together.

Electrical forces cause electrons to move.

Electricity is moving electrons.

Moving electrons cause electricity.

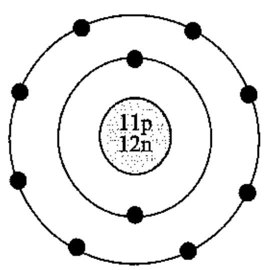


Net Charge

p – e = charge
(# of protons – # electrons = net charge)

A Sodium Ion: Na^{1+}

11 protons
10 electrons
p - e = charge
11—10 = 1
Net charge = +1



Any atom that is not neutral we call an ***ion***. Positive ions are called ***cations***. Negative ions are called ***anions***. Metals tend to become cations; non-metals tend to become anions. Cations attract anions and become ***neutral ionic compounds***

Positive sodium ions (Na^{1+}) attract negative chlorine atoms (Cl^{1-}) to make the ***ionic compound*** of NaCl: sodium chlorine, table salt.

Lightening is a huge build up of **static electricity** in the clouds, just like when you drag your feet across a carpet. When enough charge is built up to break through the air (ionizing it), lightening occurs, releasing the charge. You discharge static electricity when you touch a doorknob.

Charged objects try to discharge because all objects want to be electrically neutral.

Ionic Notation

Two easy steps:

1) Give the element symbol (found from number of protons). 11 protons is "sodium", or "Na".

11 protons; 10 electrons

$$Na^{1+}$$

2) Put the charge in the upper right corner (from p – e = charge and 11 - 10 = +1)

This ion notation tells us a sodium atom (11 protons) lost 1 electron (10 electrons) to become a positive ion.

Example: Give the ion notation for an atom with 8 protons and 10 electrons.

Protons: 8
Element: Oxygen (O)
Charge: p - e = charge
8 - 10 = - 2

Ionic notation:

$$O^{2-}$$

Name: ____________________

Period: ____________________

Conductors versus Insulators

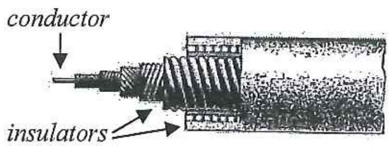
Conductors of electricity also conduct heat, thermal energy.

Conductors allow electricity to flow. Metals tend to be excellent conductors.

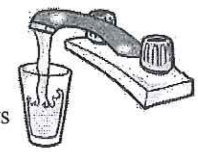
Insulators resist the flow of electricity. Conductors tend to be light or have "air holes".

Conductors tend to feel cold because they accept your heat easier.

Electrical wires have a metal center to conduct electricity surrounded by insulation for protection.



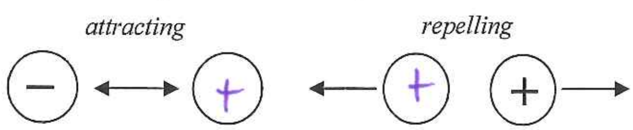
Pure water is a poor conductor: good for drinking, not so good for heat conduction. Sports drinks add salts and salt water is a very good thermal conductor.



1. Insulator	A. The charge that attracts protons.
2. Conductor	B. An atom with a different number of electrons than protons.
3. Positive	C. A material that resists the flow of electricity.
4. Negative	D. The caused by the flow of electrons.
5. Electricity	E. The charge that attracts electrons.
6. Ion	F. A material that does not resist electricity.

1. Electric charge	A. A unit in measuring the amount of charge
2. Static electricity	B. The pushes and pulls that electric charges exert on each other
3. Electrical force	C. Property of matter responsible for electrical events; it has two forms, positive and negative.
4. Coulomb	D. An object that has equal amounts of positive and negative charges.
5. Electrically neutral	E. A buildup of charge on an object.

What are the charges of the second objects?



An atom that loses electrons becomes positive/negative.

An atom that gains electrons becomes positive/negative.

Insulator or Conductor?

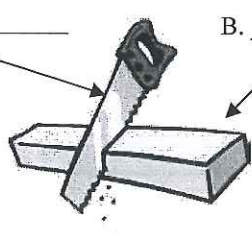
____ Silver	____ Glass	____ Gold
____ Wood	____ Copper	____ Styrofoam
____ Air	____ Pure water	____ Aluminum

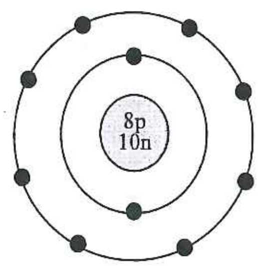
What is the charge of an atom with 12 electrons and 10 protons?

What element is it? Cation or anion?

Label the parts of the object as conductor or insulator.

A. ________________ B. ________________



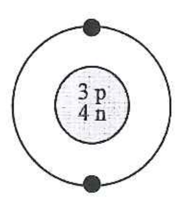


Protons:
Electrons:
Net Charge:
Neutral or Ion?
(Cation or Anion)
Ion Notation:

(charge) __

(symbol)→ ____

After you rub a balloon on your hair it might stick to a wall. Why? Be specific.



Protons:
Electrons:
Net Charge:
Neutral or Ion?
(Cation or Anion)
Ion Notation:

What would happen if this atom were brought close to the atom above it?

Name: ____________________

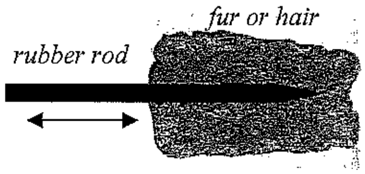
Period: ____________________

Separating Charge

Charges (electrons or protons) can never be destroyed, but they can be separated so that there is a difference of charge. When objects are positive or negative, it is because charges (usually electrons) have been moved.

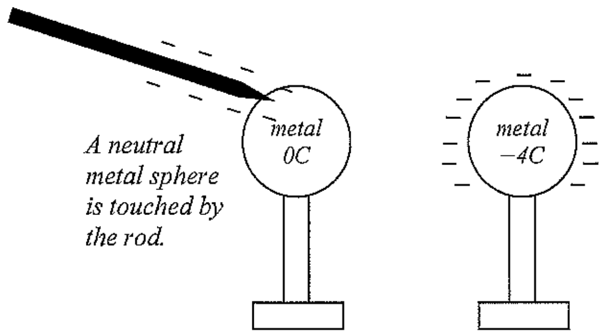
By Contact

If you drag your feet across a carpet you will gain static electricity, but you don't have to drag your feet. Any contact between certain materials will separate charge. Dragging or rubbing just speeds up the process. Both conductors and insulators can be charged thru contact.



Rubbing only transfers electrons from the fur to the rod faster.

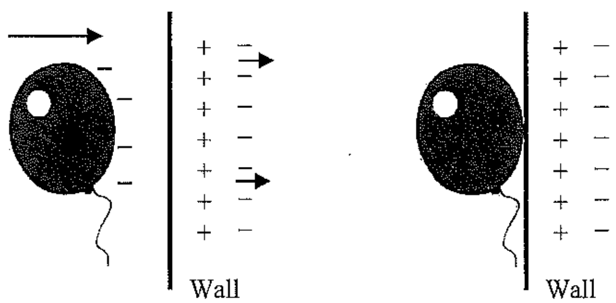
A neutral metal sphere is touched by the rod.



After it is touched the metal sphere has a negative charge because it gained electrons from the rubber rod. It has been charged by contact (touching). Being a conductor, the electrons spread out across the sphere.

By Polarization

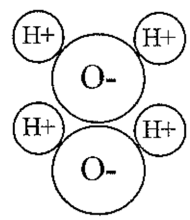
Insulators and conductors can seem to have a charge by polarization. In polarization electrons shift position, but remain on the object. A polarized object still has a net charge of zero.



When a balloon is charged by contact (rubbed with fur) it gains electrons, becoming negative. The electrons in the wall are repelled, shifting slightly away from the balloon, leaving a net positive charge on the wall's surface. The balloon then is attracted to the wall and sticks.

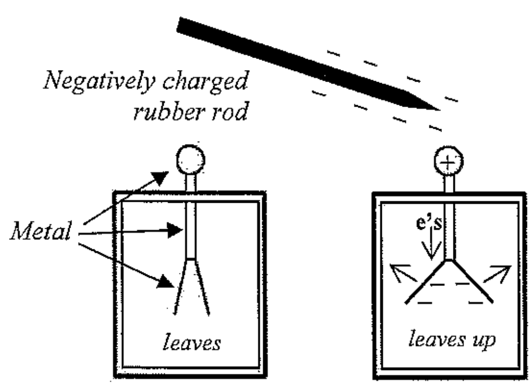
Water molecules are also polarized.

Oxygen has more protons than Hydrogen. So Hydrogen's electron is more attracted to Oxygen's protons and spend more time around Oxygen, making it more negative. Water's polarization allows it to chain thru cohesion (important for plants) and makes it a nearly universal solvent, since it can dissolve many substances.



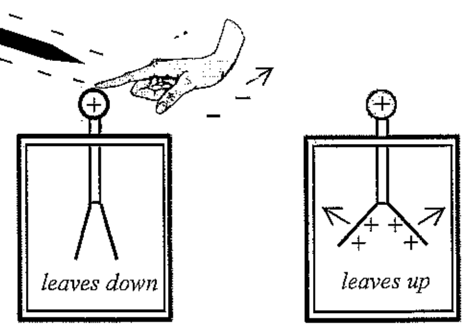
By Induction

Induction forces a charge on an object by giving an alternate path for charges to flow. Induction only works for conductors (like metals) and always induces a charge opposite to the first charged object.



Electroscope

The electroscope is now polarized, with positive and negative sides.



When a negatively charged object comes close, free electrons move away, down the metal of the electroscope to the thin metal leaves. Since both are negative, the leaves and repel each other, flying apart.

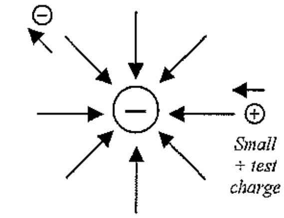
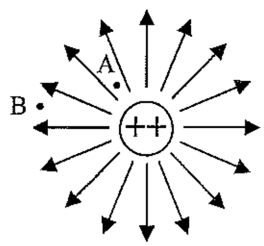
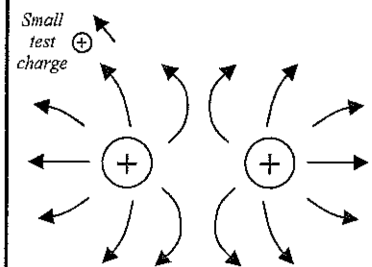
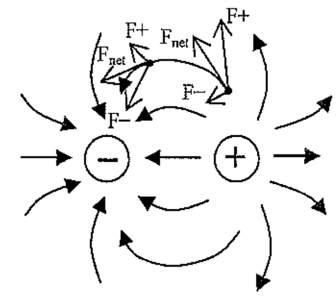
By touching the electroscope, the electrons can move farther away from the negative object, to your body. Since electrons have been lost, the electroscope now has an net positive charge and the leaves again fly apart.

Name: ____________________

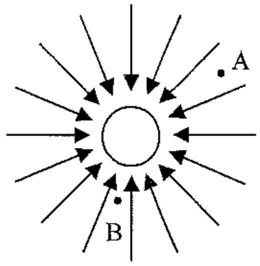
Period: ____________________

Electric Field Basics

Drawing E We use arrows to show the direction and strength of electric fields. The following diagrams visually demonstrate the rules for drawing electric field lines.

E points the direction a positive charge would move.	**More lines = stronger E.**	**Electric field lines never cross.**	**F_e is always tangent to E.**
			
E points toward negatives because negatives attract positives. Electrons move the opposite direction of E.	*The field is stronger at A because the lines are closer than at B.*	*Field lines point away from + charges, because a + test charge would be repelled and move away.*	*F_{net} is tangent to E at any point. F+ is the component due to the + charge and F− is due to the − charge.*

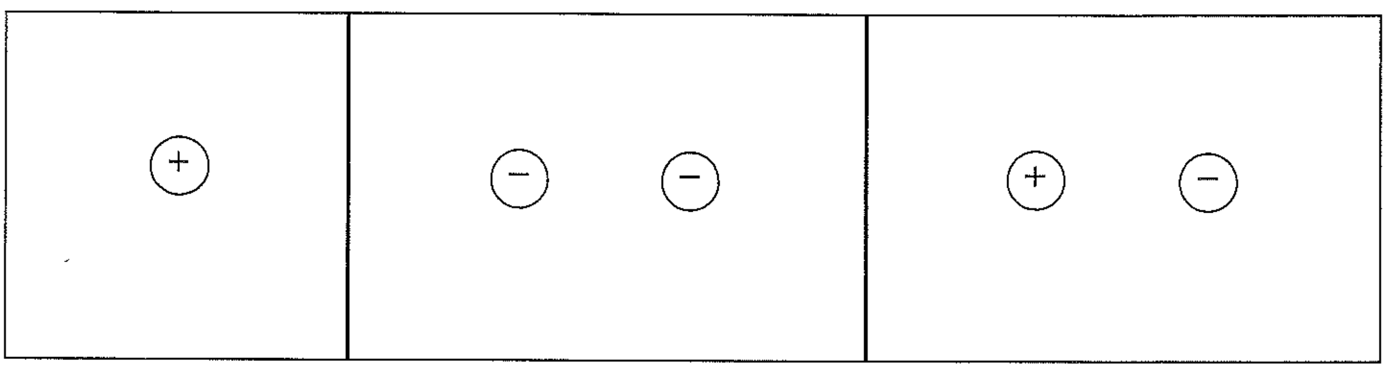
1. Electric field lines point the direction a positive charge would move. Positive charges move __________ from positive charges and ___________ negative charges. So, electric field lines point __________ from positive charges and __________ negative charges.



2. A. Is this a + or − charge?
   B. Why?

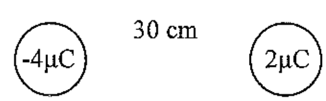
   C. Is the field stronger at point A or at point B?
   D. Why?
   E. How would the picture change if the amount of charge decreased?

3. Draw the electric field around the following.



4. How much charge do 150 electrons have?

5. How many electrons are necessary to make 3.5×10^{-18} C?



6. How much force is felt between the charges shown at the right.

Name: ____________________

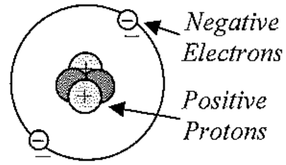
Period: ____________________

Electric Charge

Electricity

Electricity is moving electrons; Protons can't move.

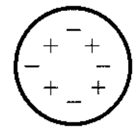
Electrons can move, but protons are held together in the nucleus by the ***strong nuclear force***, the strongest force in nature.



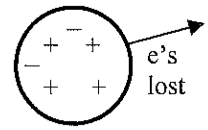
Electricity comes from electrons moving between atoms.

Charge

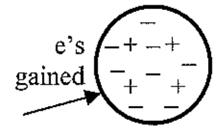
Objects can be positive, negative, or neutral. The unit of charge is the ***coulomb*** (C).



A neutral object has an **equal number** of protons and electrons.



A positive object has **lost electrons**, so it has more protons than electrons.

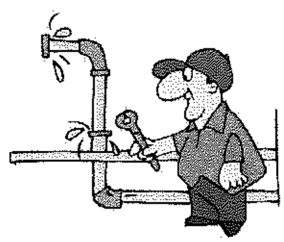


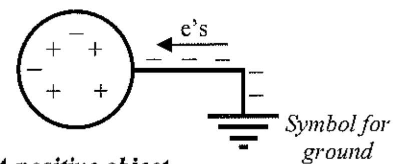
A negative object has **gained electrons,** so it has more electrons than protons.

Ground

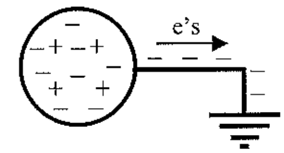
Ground (the earth) can take or give an infinite number of electrons. Ground is electrically neutral. Both positive and negative charges will neutralize when grounded.

To ground something you can often touch it to a pipe. Metal pipes are good electrical conductors and usually connected to other pipes and eventually to the actual ground.





A positive object **will take electrons** from ground and become neutral.

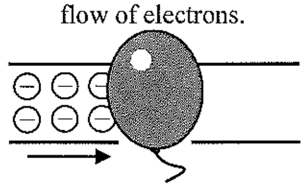


A negative object **will give electrons** to ground and become neutral.

Insulator vs. Conductor

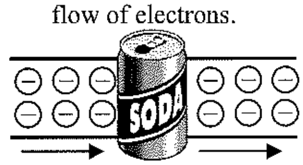
A good insulator is a bad conductor, and vice versa. The better the conductor, the easier electrons can flow thru the material.

Insulators resist the flow of electrons.



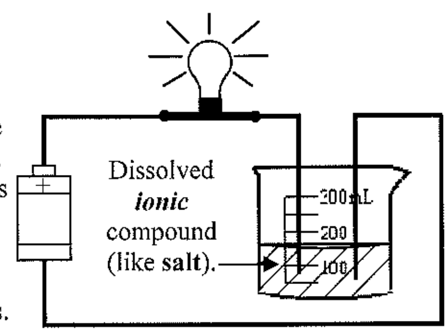
Electrons can be forced thru an insulator by enough force (called "breakdown voltage").

Conductors allow the flow of electrons.



Metals tend to be good conductors because their outer electrons are free to move.

Dissolved ionic compounds are conductors and are called electrolytes. The salt in our diets allows electricity to flow in our bodies, like in our nerves and muscles.



Electric Charge

The unit of charge is a fundamental quantity and is measured in Coulombs (C).

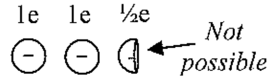
Electron Charge

1 electron =

-1.602×10^{-19} Coulombs

The charge of a proton is the same as an electron, only positive: **1 proton = $+1.602\times10^{-19}$C.**

The smallest units of charge are the proton and the electron. You cannot have part of an electron, because it would lose its negative charge. Therefore, you cannot have less than -1.602×10^{-19}C of charge and any amount of charge must be multiples of this number. You can have 12 or 13 electrons, but not 12.2 or 12.5 electrons!



Electric charge is quantized, meaning the amount of charge must always be in multiples of e. You can never have part of an electron or proton.

Ex: What is the charge of an object that gains 1.2×10^8 electrons?

Do a conversion:

$$\left(\frac{1.2\times10^{8}\cancel{e}}{1}\right)\left(\frac{-1.602\times10^{-19}\text{C}}{1\cancel{e}}\right)=-1.92\times10^{-11}\text{C}$$

Ex: How many electrons are gained or lost if an object has a charge of 4.6μC (microcoloumbs)?

$$\left(\frac{4.6\times10^{-6}\cancel{\text{C}}}{1}\right)\left(\frac{1\text{e}}{-1.602\times10^{-19}\cancel{\text{C}}}\right)=-2.87\times10^{-13}\text{e}$$

The negative means it lost e's (+ object).

Electric Charge and Force Skills Sheet

Prefixes:
Mega (M) = $\times 10^{6}$
Kilo (k) = $\times 10^{3}$
Centi (c) = $\times 10^{-2}$
Milli (m) = $\times 10^{-3}$
Micro (μ) = $\times 10^{-6}$
Nano (n) = $\times 10^{-9}$

1. Prepare these numbers for calculations by putting them into standard units:
   A. 15 μC B. 4.9 nm C. 8 MHz D. 6 mm E. 7 centicoulombs
   15×10^{-6} C

2. ~~How much charge does 1,200 electrons have?~~

3. An object has a charge of 2.4 μC.
   A. Is it positive or negative?
   B. Did it gain or lose electrons?
   ~~C. How many electrons were gained or lost?~~

Electron Charge
$1\,electron = -1.602\times10^{-19}\,C$

4. ~~How many electrons were gained or lost by a 4.5 milliC charge?~~

5. Possible or impossible:
   A. 12 electrons B. 15.5 electron C. 6.3 electrons D. 1,507 electrons

---

6. A 3 C charge is 4 mm away from a 6 C charge.
   Find the force between them.

7. A 7.2 μC charge is 20 cm away from a 3.8 μC charge. Find the force.

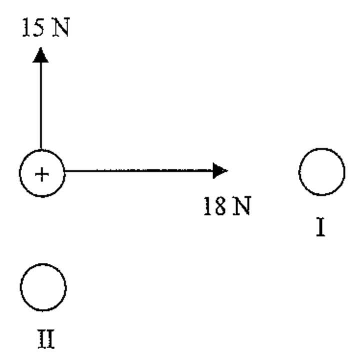
Coulomb's Law

$$F_e = k_c \frac{q_1 q_2}{r^2}$$

Electric Force (*in N*) → F_e
Charge 1 (*in Coulombs*) → q_1
Charge 2 (*in C*) → q_2
Distance between the two charges (*in m*) → r^2
Coulomb's Constant $= 9\times10^{9}\,Nm^2/C^2$ → k_c

8. How does the electric force change?
   A. If one of the charges is tripled?
   B. If the distance doubles?
   C. If one of the charges is halved?
   D. If the distance is halved?

9. Two electric forces are acting on a positive charge, as seen at the right.
   A. Using the ideas of attraction and repulsion, decide whether the two blank charges are positive or negative.



   ~~B. Calculate the net force on the charge (*including magnitude and direction*).~~
   ~~C. If the positive charge has a mass of 0.65 kg, what is its acceleration?~~
   ~~D. How much force is acting on charge I?~~

Speed in m/s

Electric Charge and Force

Prefixes:
Mega (M) = x10^6
Kilo (k) = x10^3
Centi (c) = x10^{-2}
Milli (m) = x10^{-3}
Micro (µ) = x10^{-6}
Nano (n) = x10^{-9}

1. Prepare these numbers for calculations by putting them into standard units:
   A. 15 µC — $15\times10^{-6}C$
   B. 4.9 nm — 4.9×10^{-9}
   C. 8 MHz — 8×10^{6}
   D. 6 mm — 6×10^{-3} or .006
   E. 7 centicoulombs — 7×10^{-2} or .07

2. How much charge does 1,200 electrons have?

$$\frac{1{,}200\cancel{e}}{1}\left(\frac{-1.602\times10^{-19}C}{1\cancel{e}}\right)=1.92\times10^{-16}C$$

Electron Charge
1 electron = -1.602 x 10^{-19} C

3. An object has a charge of 2.4 µC.
   A. Is it positive or negative?
   B. Did it gain or lose electrons?
   C. How many electrons were gained or lost? div.

$$\left(\frac{2.4\times10^{-6}\cancel{C}}{1}\right)\left(\frac{1e}{-1.602\times10^{-19}\cancel{C}}\right)= -1.498\times10^{13}\text{ electrons}$$

4. How many electrons were gained or lost by a 4.5 milliC charge? div.

$$\frac{4.5\times10^{-3}C}{1}\left(\frac{1e}{-1.602\times10^{-19}C}\right)= -2.8\times10^{16}\text{ electrons}$$

5. Possible or impossible:
   A. 12 electrons — yes
   B. 15.5 electron — No
   C. 6.3 electrons — N
   D. 1,507 electrons — y

Coulomb's Law

$$F_e = k_c\frac{q_1q_2}{r^2}$$

Electric Force (*in N*); Charge 1 (*in Coulombs*); Charge 2 (*in C*); Distance between the two charges (*in m*); Coulomb's Constant = 9 x 10^9 Nm^2/C^2

6. A 3 C charge is 4 mm away from a 6 C charge. Find the force between them.

$$F=\frac{9\times10^9(3)(6)}{(.004)^2}=1.01\times10^{16}N$$

Repel

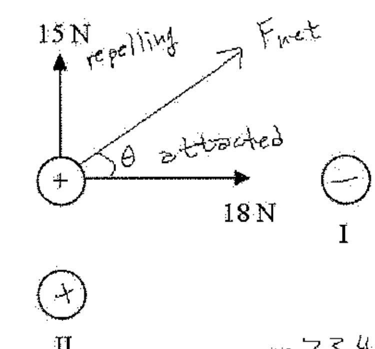
same as $(4\times10^{-3})^2$

7. A 7.2 µC charge is 20 cm away from a 3.8 µC charge. Find the force.

$$F=9\times10^9\frac{(7.2\times10^{-6})(3.8\times10^{-6})}{(.2)^2}=6.16\text{ N}$$

Repel

8. How does the electric force change?
   A. If one of the charges is tripled? 3F (3times)
   B. If the distance doubles? 1/4 F
   C. If one of the charges is halved? F/2
   D. If the distance is halved? 4X force



$15^2+18^2=c^2$ c = 23.4 N
θ = 39.8°

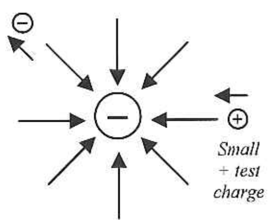
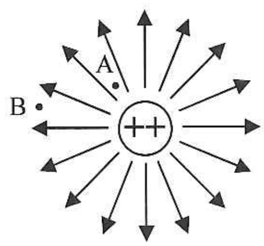
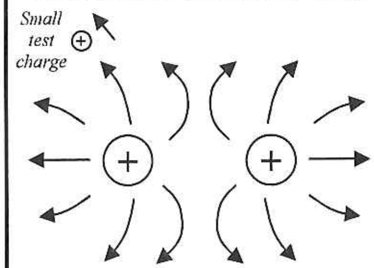
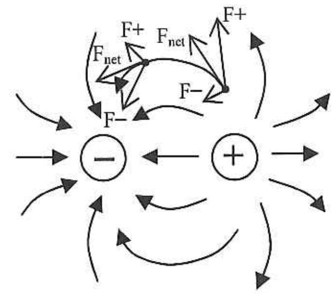
9. Two electric forces are acting on a positive charge, as seen at the right.
   A. Using the ideas of attraction and repulsion, decide whether the two blank charges are positive or negative.
   B. Calculate the net force on the charge (*including magnitude and direction*).
   C. If the positive charge has a mass of 0.65 kg, what is its acceleration?
      F=ma $a=\frac{F}{m}=\frac{23.4}{.65}=36\ m/s^2$
   D. How much force is acting on charge I?
      same: 18N only to Left

Name: ____________________

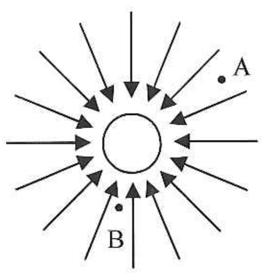
Period: ____________________

Electric Field Basics

Drawing E We use arrows to show the direction and strength of electric fields. The following diagrams visually demonstrate the rules for drawing electric field lines.

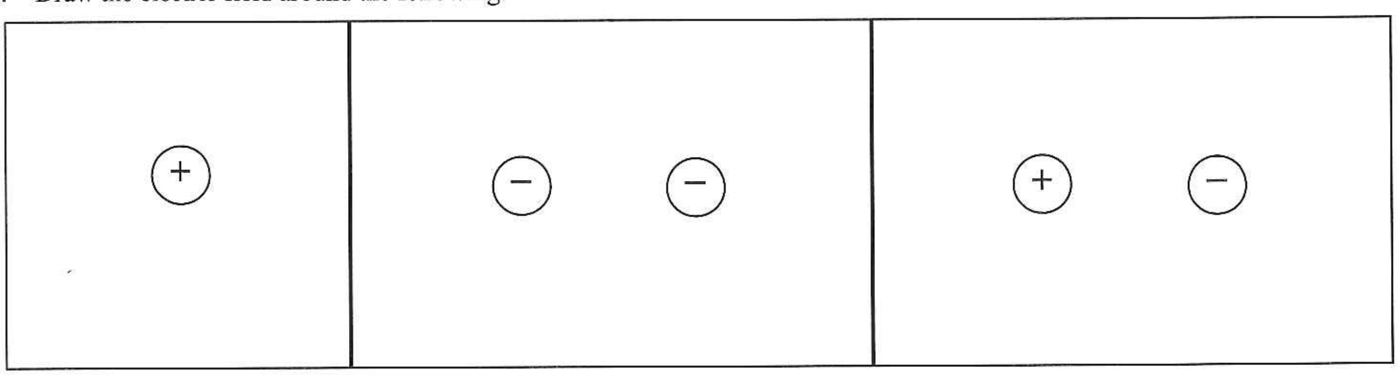
E points the direction a positive charge would move.	**More lines = stronger E.**	**Electric field lines never cross.**	**F_e is always tangent to E.**
			
E points toward negatives because negatives attract positives. Electrons move the opposite direction of E.	*The field is stronger at A because the lines are closer than at B.*	*Field lines point away from + charges, because a + test charge would be repelled and move away.*	*F_{net} is tangent to E at any point. F+ is the component due to the + charge and F− is due to the − charge.*

1. Electric field lines point the direction a positive charge would move. Positive charges move __________ from positive charges and ___________ negative charges. So, electric field lines point __________ from positive charges and __________ negative charges.



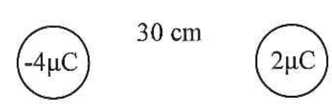
2. A. Is this a + or − charge?
   B. Why?
   C. Is the field stronger at point A or at point B?
   D. Why?
   E. How would the picture change if the amount of charge decreased?

3. Draw the electric field around the following.



4. How much charge do 150 electrons have?

5. How many electrons are necessary to make 3.5×10^{-18} C?



6. How much force is felt between the charges shown at the right.

Name: ____________________

Period: ____________________

Electric Field Basics

Drawing E We use arrows to show the direction and strength of electric fields. The following diagrams visually demonstrate the rules for drawing electric field lines.

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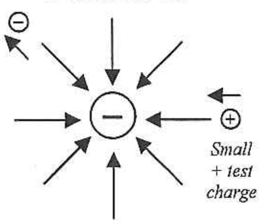
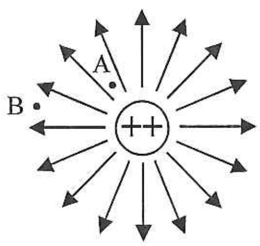
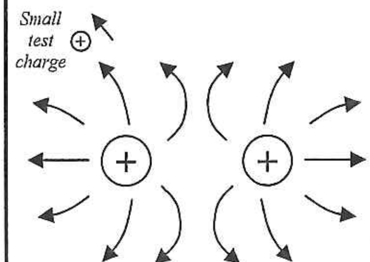
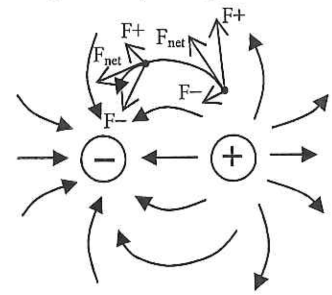
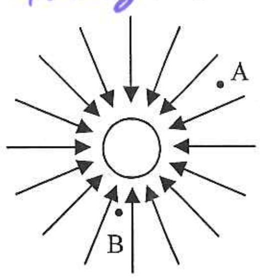
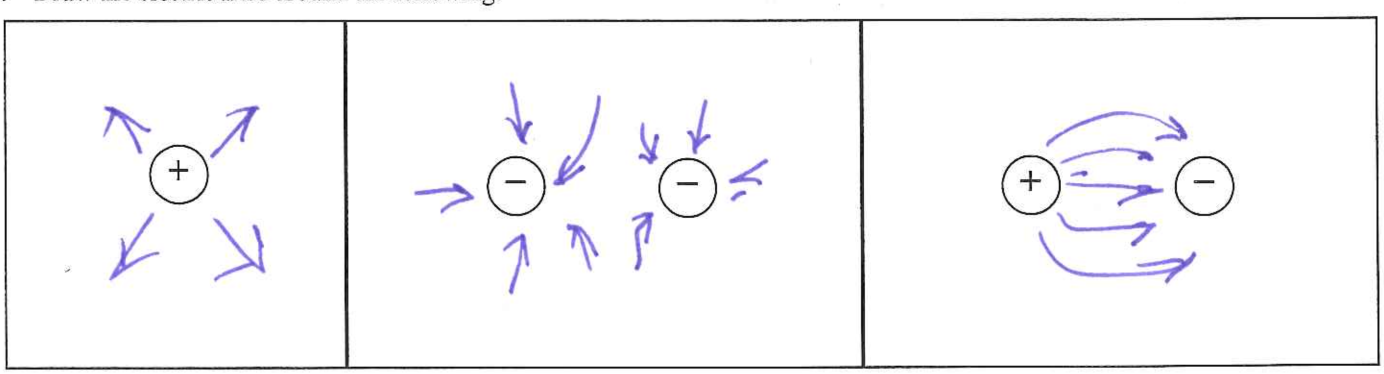
			
E points toward negatives because negatives attract positives. Electrons move the opposite direction of E.	*The field is stronger at A because the lines are closer than at B.*	*Field lines point away from + charges, because a + test charge would be repelled and move away.*	*F_{net} is tangent to E at any point. F+ is the component due to the + charge and F− is due to the − charge.*

1. Electric field lines point the direction a positive charge would move. Positive charges move away from positive charges and toward negative charges. So, electric field lines point away from positive charges and towards negative charges.



2. A. Is this a + or − charge? Neg.
   B. Why? towards
   C. Is the field stronger at point A or at point B? A
   D. Why? Close
   E. How would the picture change if the amount of charge decreased?
   fewer lins

3. Draw the electric field around the following.



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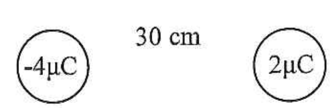


6. How much force is felt between the charges shown at the right.

Name: ____________________

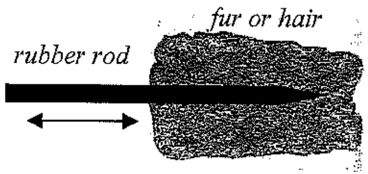
Period: ____________________

Separating Charge

Charges (electrons or protons) can never be destroyed, but they can be separated so that there is a difference of charge. When objects are positive or negative, it is because charges (usually electrons) have been moved.

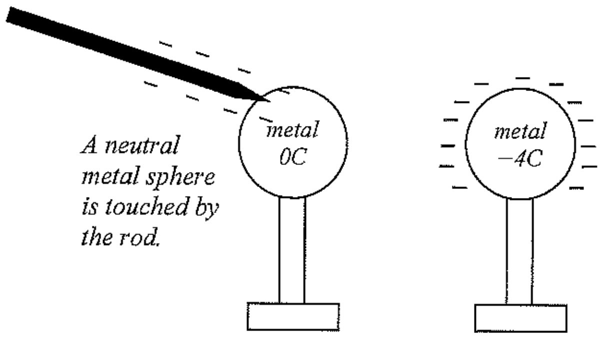
By Contact

If you drag your feet across a carpet you will gain static electricity, but you don't have to drag your feet. Any contact between certain materials will separate charge. Dragging or rubbing just speeds up the process. Both conductors and insulators can be charged thru contact.



Rubbing only transfers electrons from the fur to the rod faster.

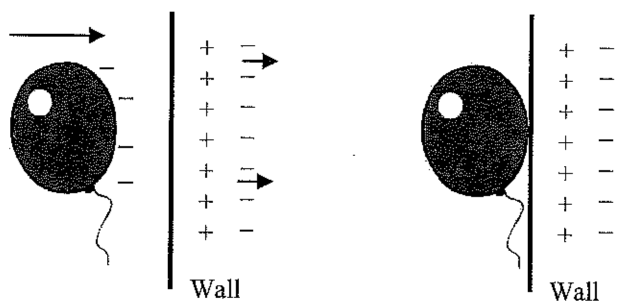
A neutral metal sphere is touched by the rod.



After it is touched the metal sphere has a negative charge because it gained electrons from the rubber rod. It has been charged by contact (touching). Being a conductor, the electrons spread out across the sphere.

By Polarization

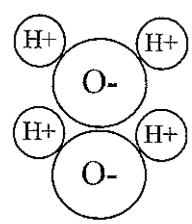
Insulators and conductors can seem to have a charge by polarization. In polarization electrons shift position, but remain on the object. A polarized object still has a net charge of zero.



When a balloon is charged by contact (rubbed with fur) it gains electrons, becoming negative. The electrons in the wall are repelled, shifting slightly away from the balloon, leaving a net positive charge on the wall's surface. The balloon then is attracted to the wall and sticks.

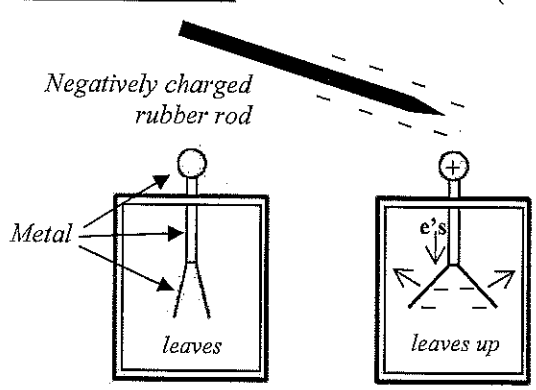
Water molecules are also polarized.

Oxygen has more protons than Hydrogen. So Hydrogen's electron is more attracted to Oxygen's protons and spend more time around Oxygen, making it more negative. Water's polarization allows it to chain thru cohesion (important for plants) and makes it a nearly universal solvent, since it can dissolve many substances.



By Induction

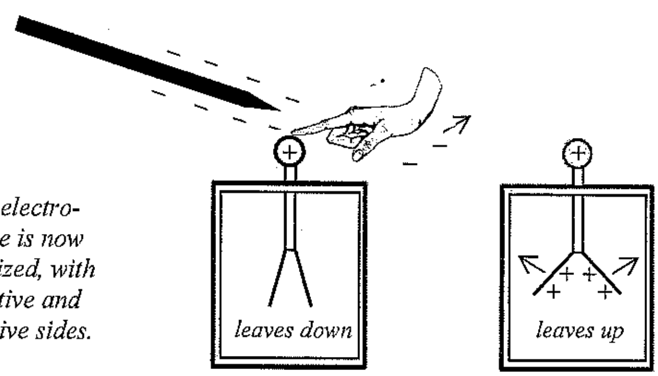
Induction forces a charge on an object by giving an alternate path for charges to flow. Induction only works for conductors (like metals) and always induces a charge opposite to the first charged object.



Electroscope

The electroscope is now polarized, with positive and negative sides.

When a negatively charged object comes close, free electrons move away, down the metal of the electroscope to the thin metal leaves. Since both are negative, the leaves and repel each other, flying apart.



By touching the electroscope, the electrons can move farther away from the negative object, to your body. Since electrons have been lost, the electroscope now has an net positive charge and the leaves again fly apart.