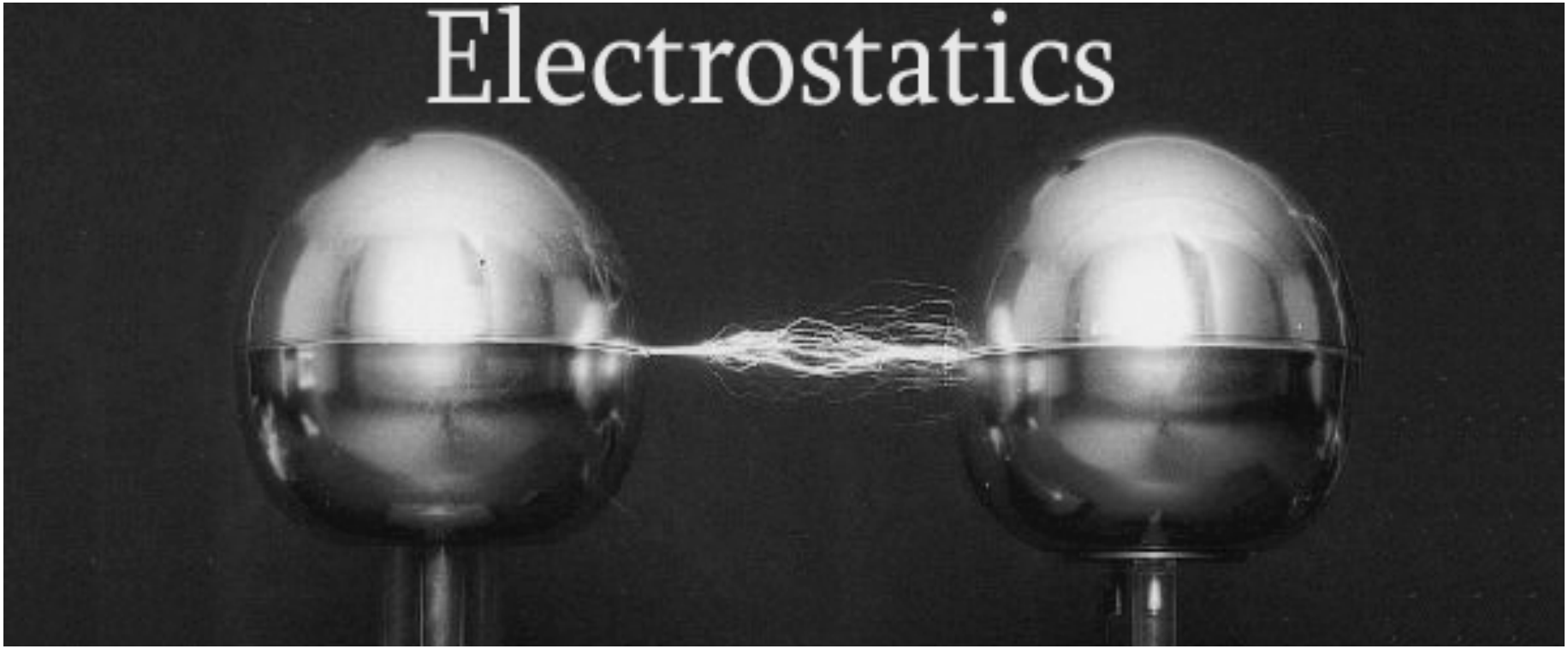
Section 12



Please pick-up section 12 packet and worksheet

Electrostatics

Electrostatics, or electricity at rest, involves electric charges, the forces between them, and their behavior in materials.

An understanding of electricity requires a step-by-step approach, for one concept is the building block for the next.

12.1
Electric Forces and Charges

Electric Forces and Charges

The fundamental rule at the base of all electrical phenomena is that like charges repel and opposite charges attract.

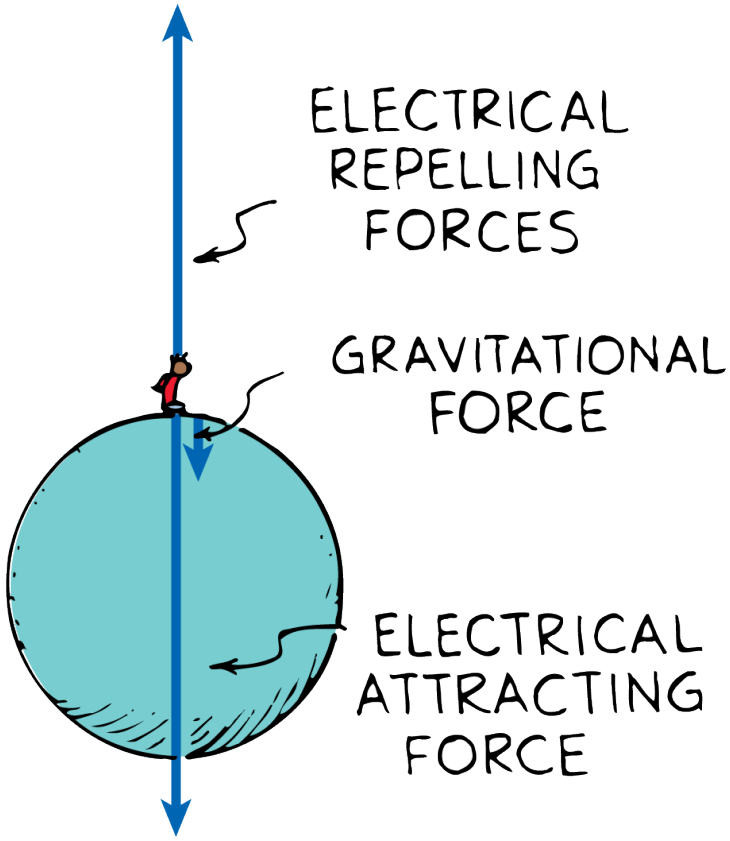
Consider a force acting on you that is billions upon billions of times stronger than gravity. Suppose that in addition to this enormous force there is a repelling force, also billions upon billions of times stronger than gravity.

The two forces acting on you would balance each other and have no noticeable effect at all. A pair of such forces acts on you all the time - electrical forces.

Electric Forces and Charges

Electrical forces have the unique property of having enormous attractive and repulsive electrical forces between the charges.

Gravitational forces, which are significantly weaker than electrical forces, only have an attractive force.

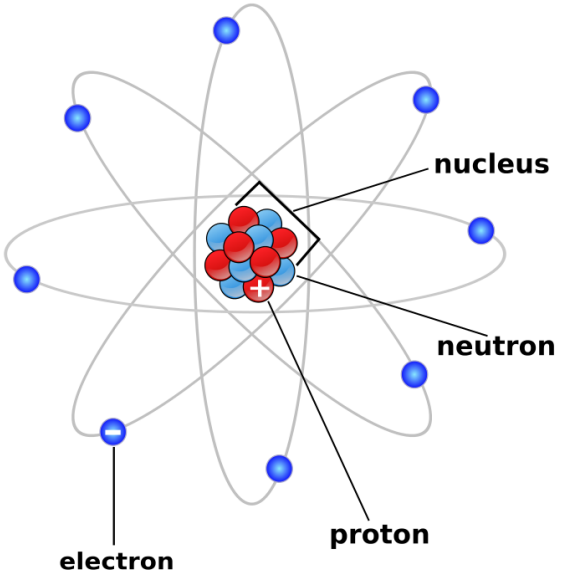


The Atom

Electrical Forces arise from particles in atoms.

- The protons in the nucleus **attract** the electrons and hold them in orbit.

- Electrons are **attracted** to protons, but electrons **repel** other electrons and protons **repel** other protons.



Electric Forces and Charges

- The fundamental electrical property to which the mutual attractions or repulsions between electrons or protons is attributed is called charge.
- By convention, electrons are negatively charged and protons positively charged.
- Neutrons have no charge, and are neither attracted nor repelled by charged particles.

Electric Forces and Charges

Here are some important facts about atoms:

- **Every atom has a positively charged nucleus surrounded by negatively charged electrons.**
- **All electrons are identical.**
- **The nucleus is composed of protons and neutrons. All protons are identical; similarly, all neutrons are identical.**

Electric Forces and Charges

Here are some important facts about atoms:

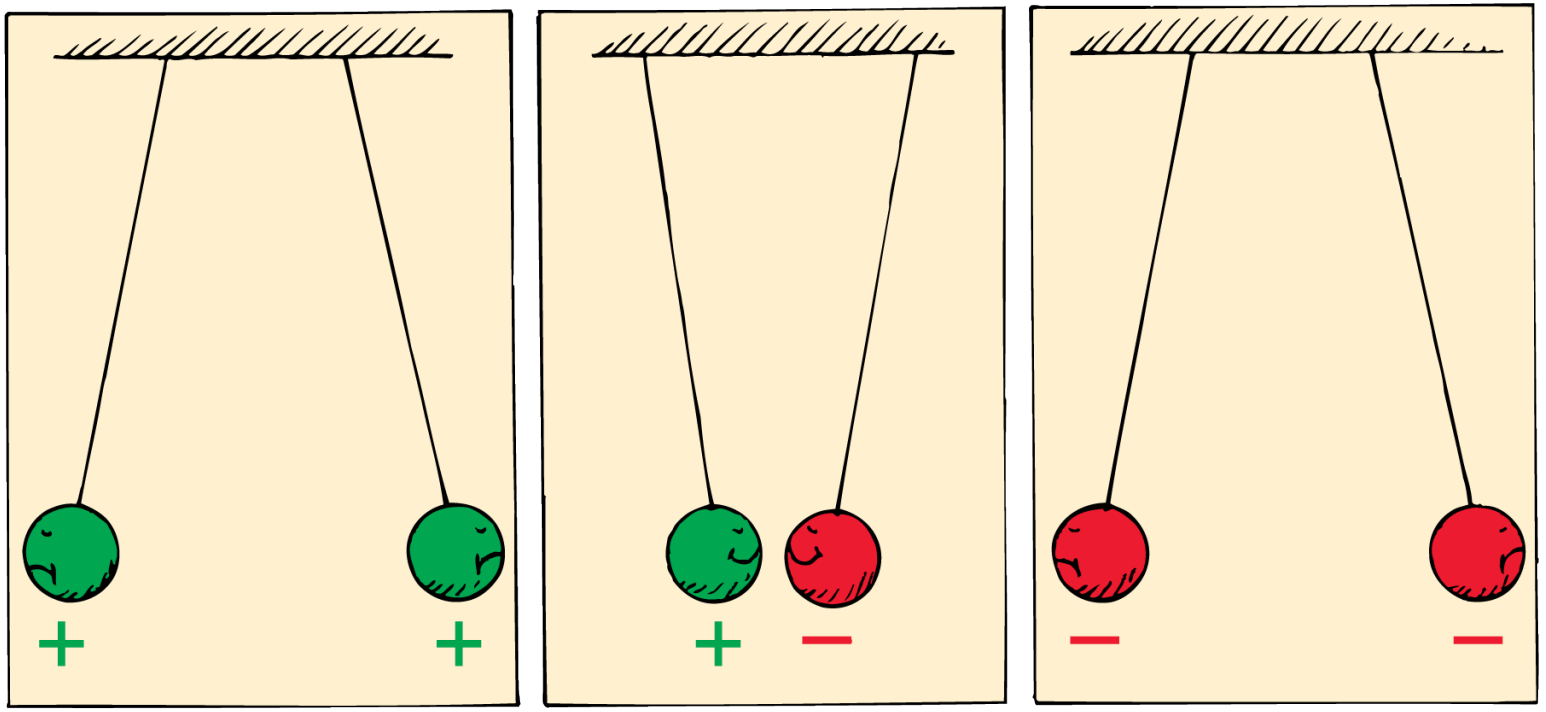
- **Atoms usually have the same number of electrons as protons, so the atom has zero net charge.**

- **A proton has nearly 2,000 times the mass of an electron, but its positive charge is equal in magnitude to the negative charge of the electron.**

Electric Forces and Charges

The fundamental rule of all electrical phenomena is that like charges repel and opposite charges attract.

The movement of these charges produce electric and magnetic fields.

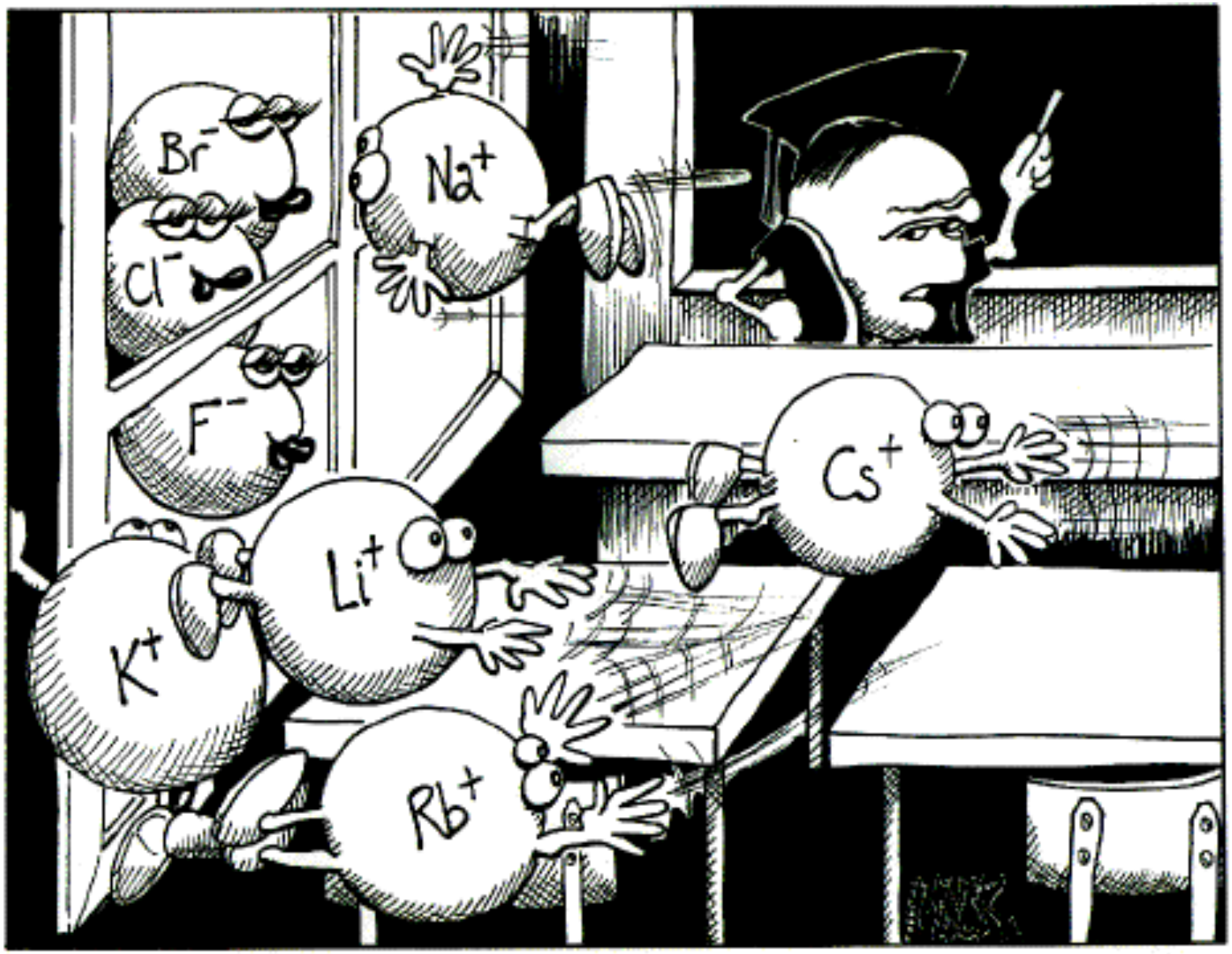


Electric Forces and Charges

CONCEPT CHECK

What is the fundamental rule at the base of all electrical phenomena?

- *Like charges repel*
- *Opposites charges attract*



"Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive...?"

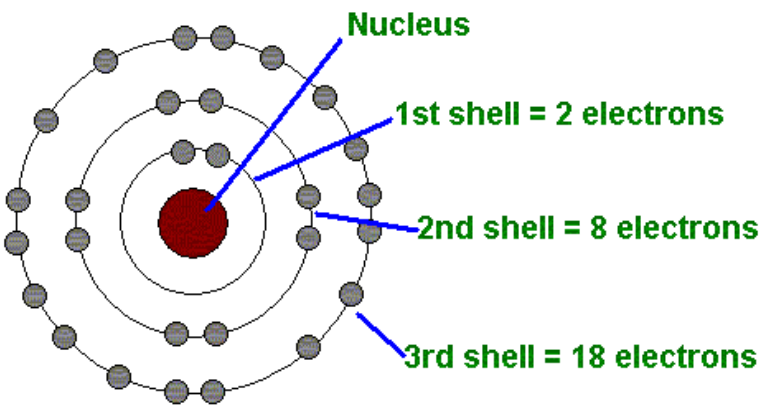
Conservation of Charge

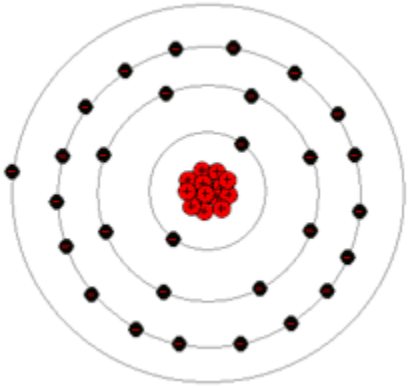
Electrically Charged Objects

- Matter is made of atoms, and atoms are made of electrons and protons which both have charges.
- An object that has equal numbers of electrons and protons has no net electric charge.
- But if there is an imbalance in the numbers, the object is then electrically charged.
- An imbalance comes about by adding or removing electrons.

Conservation of Charge

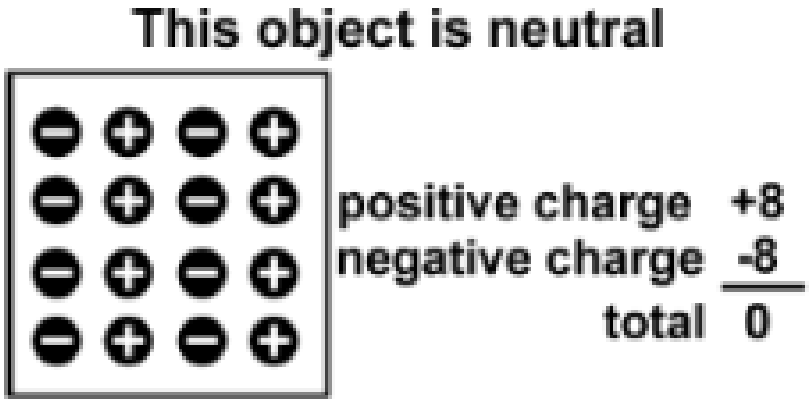
- The innermost electrons in an atom are bound very tightly to the oppositely charged atomic nucleus.
- The outermost electrons of many atoms are bound very loosely and can be easily dislodged.
- How much energy is required to tear an electron away from an atom varies for different substances.





Conservation of Charge

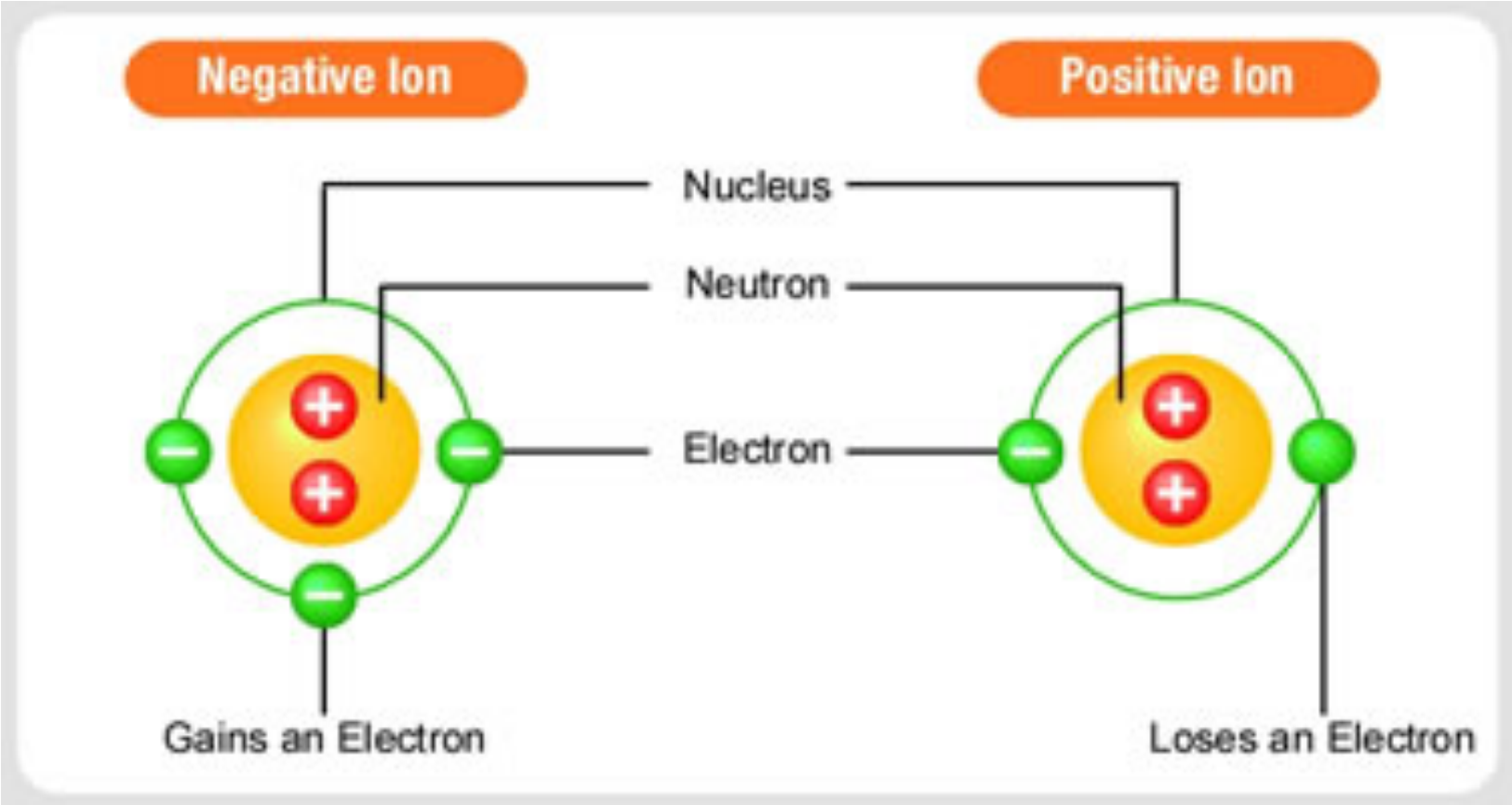
- **An object is electrically neutral when it has equal amounts of both types of charge.**



Conservation of Charge

- If an electron is removed from an atom, the atom is no longer neutral. It has one more positive charge than negative charge.
- A charged atom is called an ion.
  - A positive ion has a net positive charge; it has lost one or more electrons.
  - A negative ion has a net negative charge; it has gained one or more extra electrons.

Conservation of Charge



Principle of Conservation of Charge

Electrons are neither created nor destroyed but are simply transferred from one material to another.

This principle is known as Conservation of Charge.

Any object that is electrically charged has an excess or deficiency of some whole number of electrons - electrons cannot be divided into fractions of electrons.

This means that the charge of the object is a whole-number multiple of the charge of an electron.

Conservation of Charge

Thinker!!!

If you scuff electrons onto your shoes while walking across a rug, are you negatively or positively charged?

Conservation of Charge

CONCEPT CHECK

What causes an object to become electrically charged?

If an object gains or loses an electron

Electric Charges - Specifics

- SI Unit for charge is the Coulomb (C)
- The symbol for charge is "Q".
- Charge on a single proton or electron is referred to an elementary charge and often use, *e* , to symbolize this.
- The charge of a proton is e^+, an electron is e^-.
- The elementary charges of an object, Q, is always a multiple of this elementary charge.

Electric Charges - Specifics

Formula:

$Q = n \cdot e$

Q = Charge
n = Number of electrons or protons
e = Charge of an electrons or protons

Electric Charges - Specifics

Some important constants:

Particle	Elementary charge (e)	Mass (kg)
Proton (+)	1.6×10^{-19} C	1.67×10^{-27} kg
Electron (-)	1.6×10^{-19} C	9.11×10^{-31} kg
Neutron	0 C	1.67×10^{-27} kg

Electric Charges

Example #1

An object possess an excess of 6.0×10^6 electrons has what net charge (Q)?

$Q = n \cdot e$

$Q = (6.0 \times 10^6 \text{ electrons})(1.6 \times 10^{-19} \text{ C})$

$Q = 9.6 \times 10^{-13} \text{ C}$

Electric Charges - Specifics

Example #2

How many elementary charges of protons are required for an object to have 1 C of charge?

$Q = n \cdot e$

$1C = n\ (1.6 \times 10^{-19}\ C)$

$n = 6.25 \times 10^{18}$ protons

Electric Charges

Example #3

Which quantity of excess electrical charge can be found on an object?

a. 6.25×10^{-19} C
b. 4.8×10^{-19} C
c. 6.25 elementary charges
d. 1.60 elementary charges

Electric Charges

Example #4

What is the net electrical charge on a magnesium ion that is formed when a neutral magnesium ion loses two electrons?

a. -3.2×10^{-19} C
b. -1.6×10^{-19} C
c. 1.6×10^{-19} C
d. 3.2×10^{-19} C

Conductors and Insulators

Conductors and Insulators

- Electrons move easily in good conductors and poorly in good insulators.
- Outer electrons of the atoms in a metal are not anchored to the nuclei of particular atoms, but are free to roam in the material.
- Materials through which electric charge can flow are called **conductors**.
- Metals are good conductors for the motion of electric charges because their electrons are “loose.”

Conductors and Insulators

- Electrons in other materials—rubber and glass, for example—are tightly bound and remain with particular atoms.
- They are not free to wander about to other atoms in the material.
- These materials, known as insulators, are poor conductors of electricity.

Transferring Charges

Three ways electric charge can be transferred are by:

1. **Friction**
2. **Conduction (Contact)**
3. **Induction**

These are types of static electricity!!!

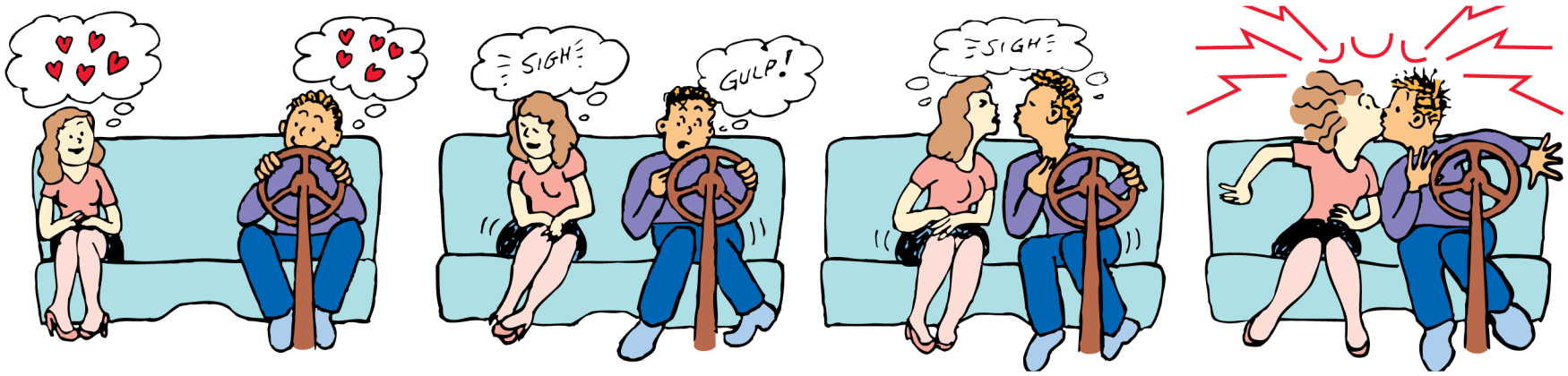
Static Electricity

Charging by Friction and Contact

- We can stroke a cat's fur and hear the crackle of sparks that are produced.
- We can comb our hair in front of a mirror in a dark room and see as well as hear the sparks of electricity.
- We can scuff our shoes across a rug and feel the tingle as we reach for the doorknob.
- Electrons are being transferred by friction when one material rubs against another.

Charging by Friction and Contact

If you slide across a seat in an automobile, you are in danger of being charged by friction.



Charging by Friction and Contact

- Electrons can also be transferred from one material to another by simply touching.
- When a charged rod is placed in contact with a neutral object, some charge will transfer to the neutral object.
- This method of charging is called charging by contact.
- If the object is a good conductor, the charge will spread to all parts of its surface because the like charges repel each other.

CONCEPT CHECK

What is the difference between a good conductor and a good insulator?

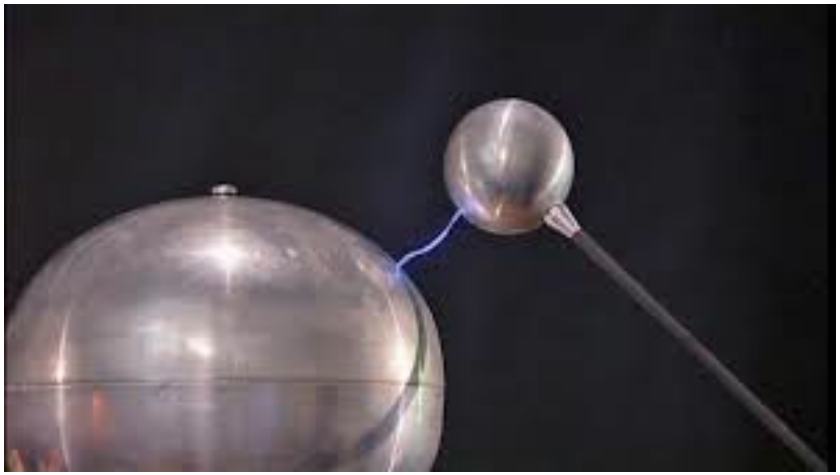
Electrons can easily move in conductors and poorly in insulators.

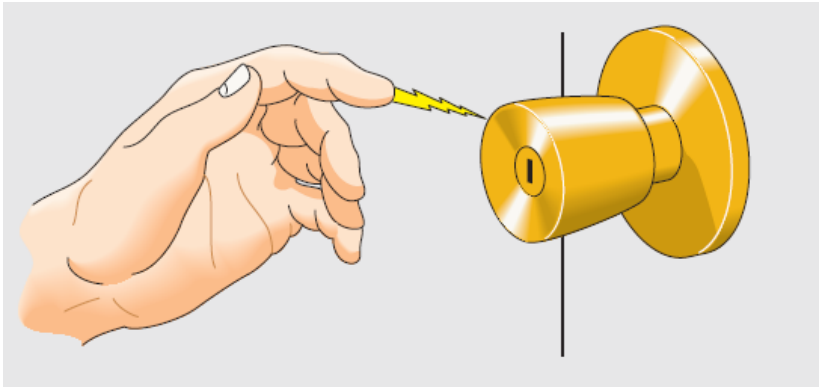
Charging by Induction

- If a charged object is brought near a conducting surface, even without physical contact, electrons will move in the conducting surface.

https://www.youtube.com/watch?v=g9GU3XpiepM

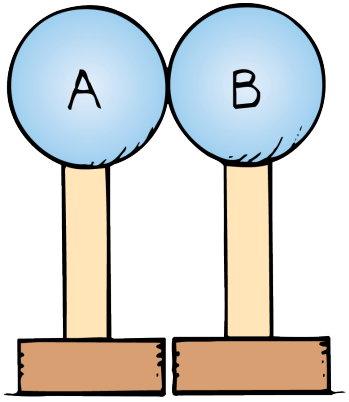
Charging by Induction

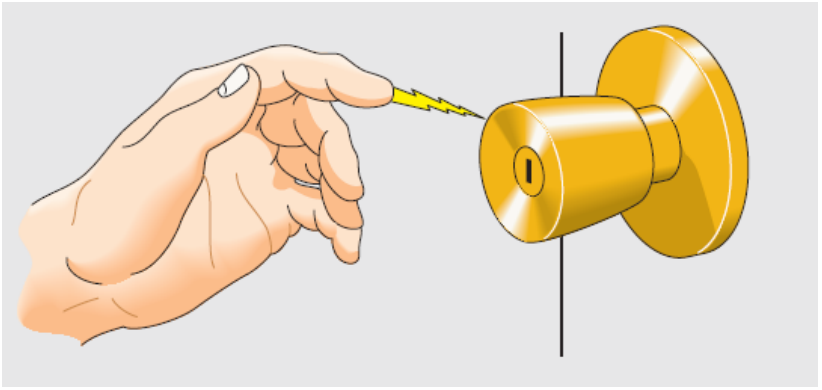




Charging by Induction

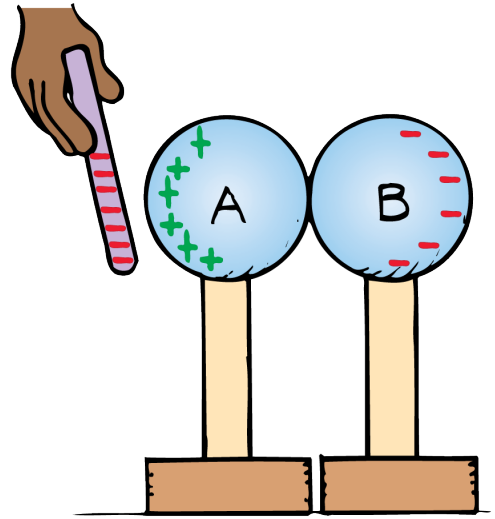
- If a charged object is brought near a conducting surface, even without physical contact, electrons will move in the conducting surface.
- Charging by induction can be illustrated using two insulated metal spheres.
- Uncharged insulated metal spheres touching each other, in effect, form a single non-charged conductor.





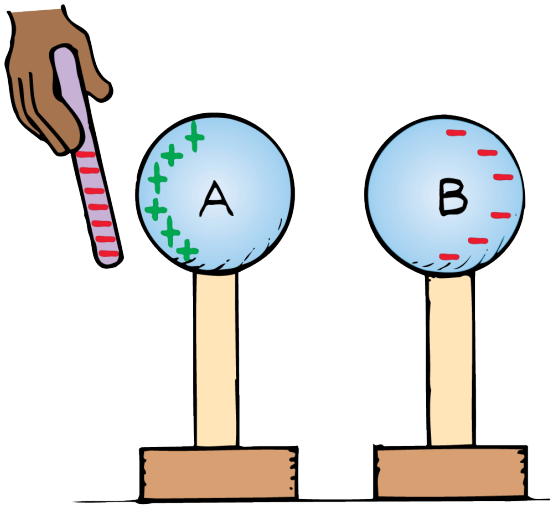
Charging by Induction

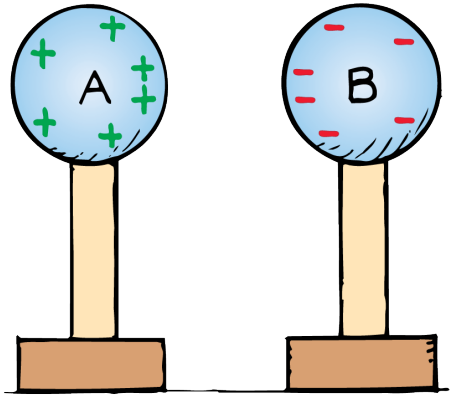
- When a negatively charged rod is held near one sphere, electrons in the metal are repelled by the rod.
- Excess negative charge has moved to the other sphere, leaving the first sphere with an excess positive charge.
- The charge on the spheres has been redistributed, or induced.



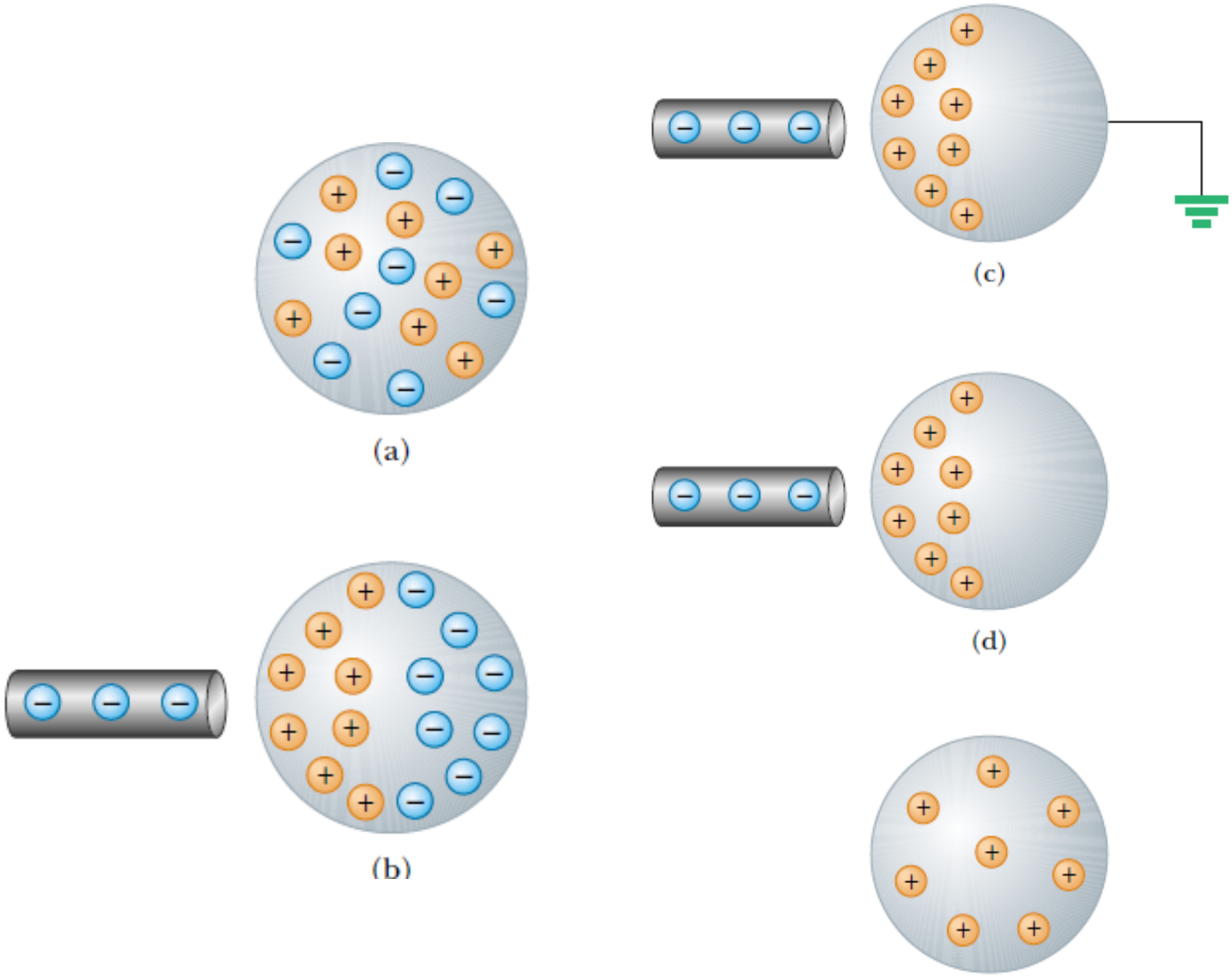
Charging by Induction

- When the spheres are separated and the rod removed, the spheres are charged equally and oppositely.
- They have been charged by induction, which is the charging of an object without direct contact.





Charging by Induction



CONCEPT CHECK

What are three ways electric charge can be transferred?

1. **Friction**
2. **Conduction (Contact)**
3. **Induction**

Electrostatics – Assessment Questions

1. If a neutral atom has 22 protons in its nucleus, the number of surrounding electrons is:

   a. less than 22
   b. 22
   c. more than 22
   d. unknown

Electrostatics – Assessment Questions

2. When we say charge is conserved, we mean that charge can:

a. be saved, like money in a bank.
b. only be transferred from one place to another.
c. take equivalent forms.
d. be created or destroyed, as in nuclear reactions.

Electrostatics – Assessment Questions

3. Which is the predominant carrier of charge in copper wire?

a. protons
b. electrons
c. ions
d. neutrons

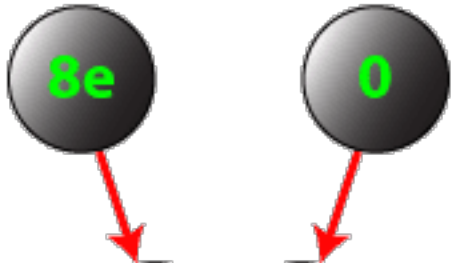
Electrostatics – Assessment Questions

4. When you scuff electrons off a rug with your shoes, your shoes are then:

   a. negatively charged.
   b. positively charged.
   c. ionic.
   d. electrically neutral.

Electrostatics – Assessment Questions

5. If a conductor carrying a net charge of 8 elementary charges is brought in contact with an identical conductor with no net charge, what will be the charge on each conductor after they are separated?



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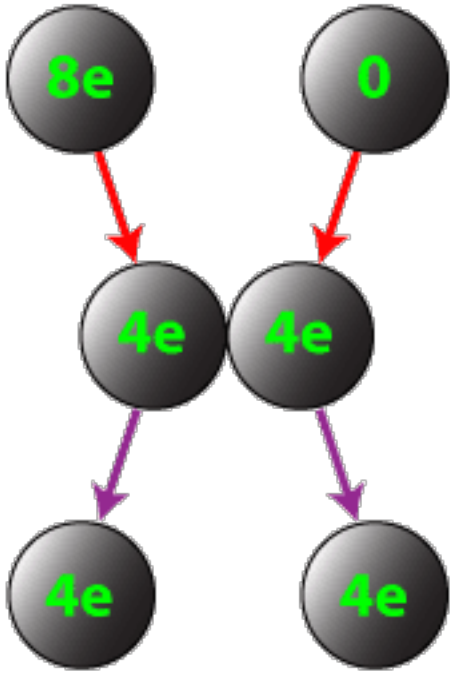
Electrostatics – Assessment Questions

6. From the previous problem, what is the net charge (in coulombs) on <u>each conductor</u> after they are separated?



6.4×10^{-19} C

Electrostatics – Assessment Questions

7. When a negatively charged balloon is placed against a non-conducting wall, positive charges in the wall are:

a. attracted to the balloon.
b. repelled from the balloon.
c. too bound to negative charges in the wall to have any effect.
d. neutralized

Electrostatics – Assessment Questions

8. Metal sphere A has a net charge of -2 units and an identical metal sphere B, has a net charge of -4 units. If the spheres are brought in contact with each other and then separated, what is the charge on sphere "B"?

-3 units

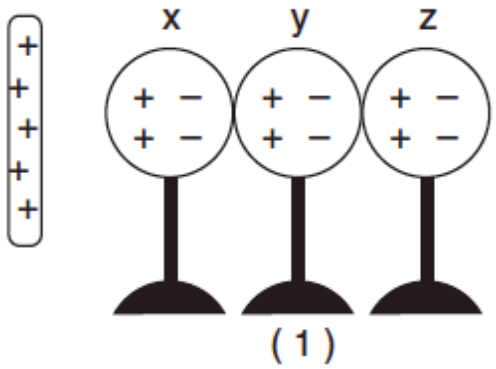
Electrostatics – Assessment Questions

9. Compared to insulators, metals are better conductors of electricity because metals contain more free:

a. Protons
b. Electrons
c. Positive ions
d. Negative ions

Electrostatics – Assessment Questions

10. Which diagram best represents the charge distribution on three neutral spheres when a positively charged rod is brought near sphere "x", but does not touch it



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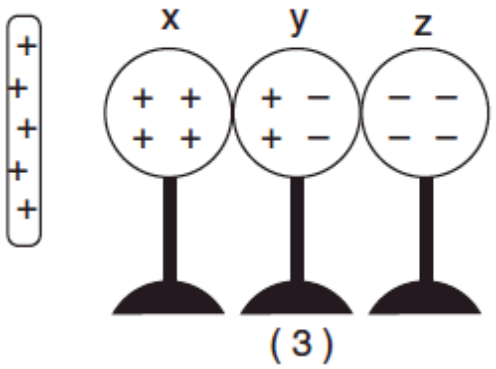

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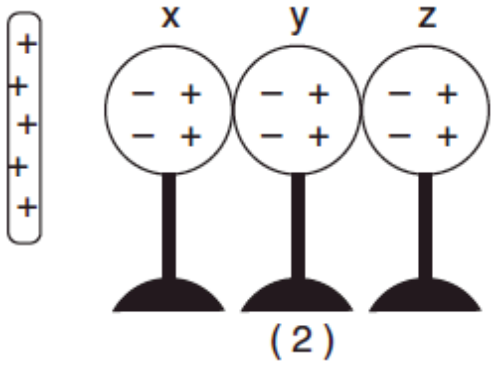

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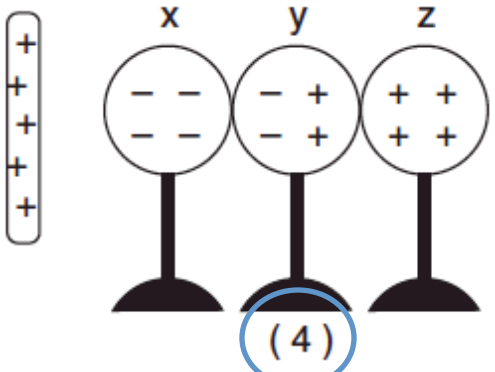

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Electrostatics – Assessment Questions

11. A positivity charged glass rod attracts object X. The net charge of object X:

a. May be zero or negative
b. May be zero or positive
c. Must be negative
d. Must be positive