شرح وأوراق عمل أول درسين من الوحدة الأولى منهج انسباير

تاريخ إضافة الملف على موقع المناهج: 2024-08-31 09:51:03

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1

Static Electricity

SECTIONS

1. Electric Charge
2. Electrostatic Force

Einstein_AE

SECTION 1

Electric Charges

Charging

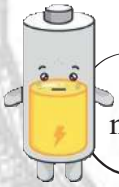
A process transfer negativity charge (electron) not positive change (proton

Electrons move easily between objects

Each atom is composed of

Protons

positive charge(+)



Electrons

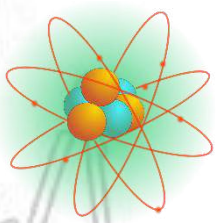
negative charge(-)

Neutrons

no charge, neutral(0)

atoms are neutral, because numberof electrons equal to number of protons

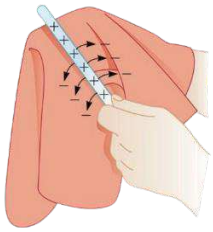
positive charge (+)	negative charge (-)
Lost or remove some electron $N_p > N_e$	Gain or add some electron $N_e > N_p$



Conservation of Charge

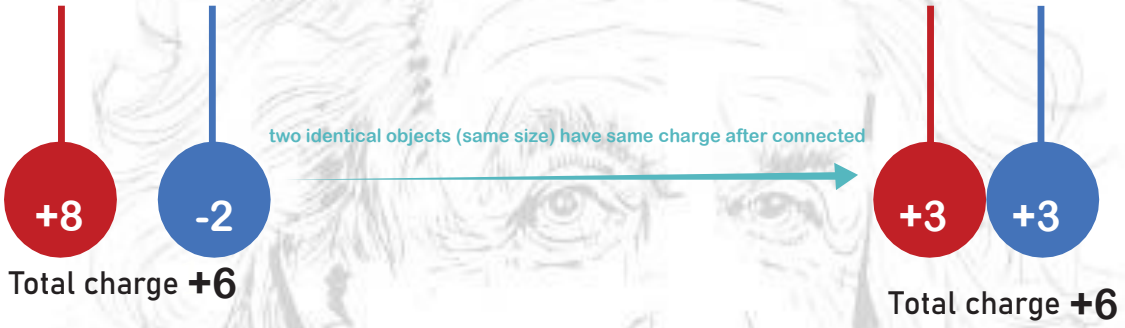
charges cannot be created nor destroyed, rather transfer from atom to another"

NOTES



- This indicates when an object loses some electrons there is another object gains these electrons
- As two charged objects are in contact, the charges transferred between them till both objects have the same potential difference
- If the two objects have the same volume (size), they will have the same amount of charge

Before VS **After**



The net initial charge of the system is equal The net final charge of the system

Charge: is a property of subatomic particles. It is scalar quantity

Quantization of Charge

"charges transfer as a multiple of the charge of electron"

Unit of charge : Coulomb (C): $1c = 1A.s$

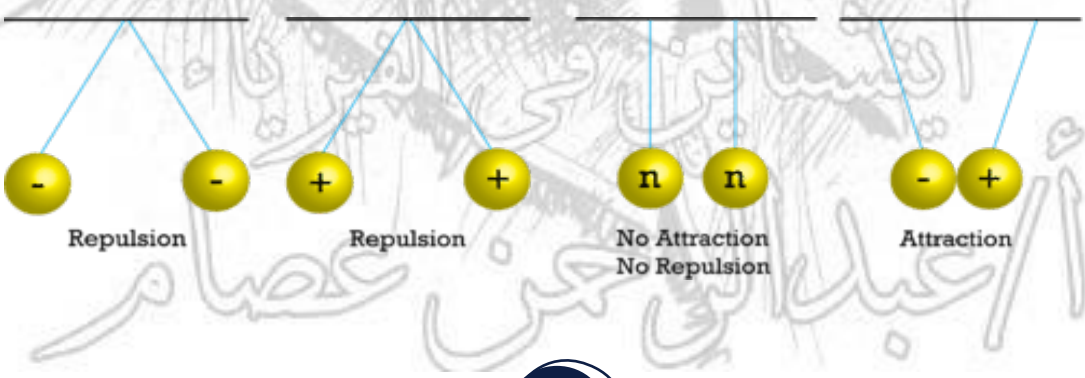
SI unit of electric current Ampere (A) where

$$q = \pm n \times e$$

Where

q	amount of charge
n	number of charges
e	elementary charge

Like charges Repel and opposite charges Attract



Questions

Check your understanding

1 Choose the correct answer:

1. One way to charge a neutral metallic with a Negative charge is to do one of the following

   ⓐ Remove some electrons ⓑ Cut of a part of the object

   ⓒ Add some electrons ⓓ Add some neutral atoms

2. The aluminum rod in the figure is positively charged. How did that happen?

   ⓐ Remove some electrons ⓑ Cut of a part of the object

   ⓒ Add some electrons ⓓ Add some neutral atoms

3. When two neutral objects are rubbed against each other, the first one gains a net charge 3 e Which of the following statements is true

   ⓐ The second gains 3 e and is positively charged ⓒ The second loses 3 e and is positively charged

   ⓑ The second gains 3 e and is negatively charged ⓓ The second loses 3 e and is negatively charged

4. What is the charge of a particle that has lost 3.5×105of its electrons?

   ⓐ $+3.2\times10^{-14}$ C ⓑ -3.2×10^{-14} C ⓒ $+5.6\times10^{-14}$ C ⓓ -5.6×10^{-14} C

5. A neutral conducting sphere has been charged with a charge $+8.32\mu C$

   Which of the following is correct about the sphere?

   ⓐ Gained 5.2×10^{13} protons ⓒ Lost 5.20×10^{13} electrons

   ⓑ Lost 8.32×10^{6} electrons ⓓ Gained 8.32×10^{6} protons

6. How many electrons does it take to make (-2.00 C) of charge?

   ⓐ 2 electron ⓑ 1.25×10^{19}electron ⓒ1.6×10^{-19} electron ⓓ3.2×10^{-19} electron

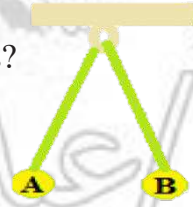
7. Which of the following is incorrect amount of charge:

   ⓐ 8.0×10^{-20} C ⓑ 1.6×10^{-16} C ⓒ 1.6×10^{-19} C ⓓ 6.4×10^{-19} C

8. A glass rod is charged by friction during which 13×10^{10} electrons are removed from the rod. What is the charge on the rod?

   ⓐ $-20.8\ nC$ ⓑ $-6.40\ nC$ ⓒ $+8.12\ nC$ ⓓ $+20.8\ nC$

9. The figure shows two isolated bodies (A and B) suspended freely. Which of the following may be true about the charge of the two objects?



ⓐ

A	B
Negative سالبة	Positive موجبة

ⓑ

A	B
Neutral متعادلة	Neutral متعادلة

ⓒ

A	B
Positive موجبة	Negative سالبة

ⓓ

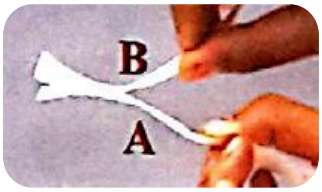
A	B
Negative سالبة	Negative سالبة

10. When you rub two neutral objects such as rubber and wool together, they become charged Which of the following statements correctly describes the combined total charge of the two objects?

ⓐ It equals zero. ⓒ It is negative.

ⓑ It is positive. ⓓ It could be negative or positive.

11. The two strips (A and B) stick together in the adjacent shape as a result of electrical charges. Which of the following is true?



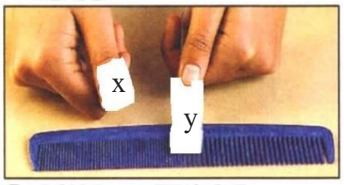
ⓐA has a positive charge while B has a negative charge.

ⓑA and B have a negative charge

ⓒA and B are negatively charged.

ⓓThe A and B segments do not carry any type of charge

12. The adjacent figure shows the position of two strips (x and y) when they are brought close to a comb due to electrical charges. Which of the following is true?



ⓐThe comb and slice carry a positive charge.

ⓑ The comb and slice x carry a negative charge.

ⓒ The comb is uncharged and the chip x carries a positive charge.

ⓓThe comb and slice y carry a positive charge.

13. How many electrons have been removed from a positively charged electroscope if it has a net charge of 9.612×10^{-11} C?

.....

.....

14. What is the charge on an electroscope that has an excess of 4.8×10^{10} electrons?

.....

.....

15. it possible to find an object with a net charge of $3 \times 10^{-19}\ C$?

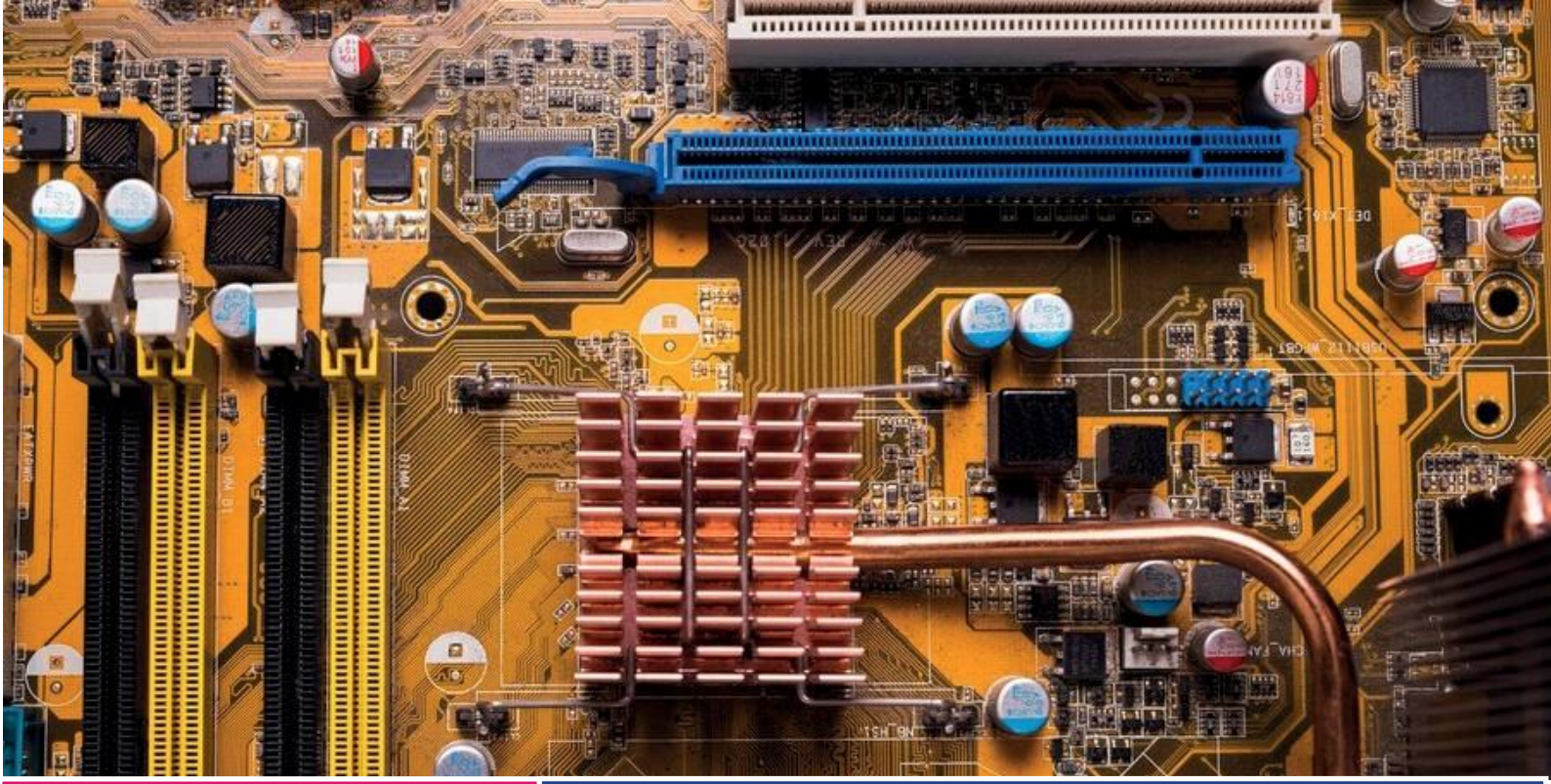
.....

.....

16. Suppose that in the oil drop experiment, Millikan tested a drop of oil carrying three basic units of charge. What is the resultant charge on the drop of oil?

.....

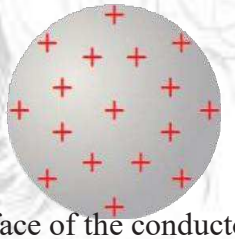
.....



SECTION 1 Conductors , Insulators

Conductors

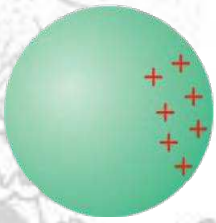
a material in which electrons are able to move easily. If a conductor is charged, the excess charges move freely on its surface. The best electrical conductors are metals (gold, iron copper, aluminum) have low electrical resistance, good contact electricity



When a charge is placed on a conductor, it is distributed over the entire surface of the conductor

Insulators

a material in which electrons are not able to move easily. If an insulator is charged the charges localized on same place. Examples of electrical insulators are plastics wood, rubber and glass have high electrical resistance, bad contact electricity



When a charge is placed on a part of an insulating material, it remains in the same place and does not move

NOTES

Even fluids such as sea water can serve as a conductor because it contains NaCl (table salt)

Na^+, Cl^- charge can help to conduct electric

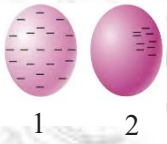
Plasma is a conductor because highly ionized gases

Questions

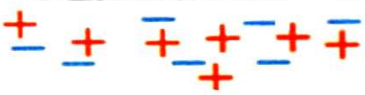
Check your understanding

1 Choose the correct answer:

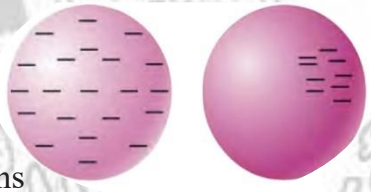
1. Which of the following are materials that have a very heigh resistance ?
   ⓐ Semiconductors ⓑ Insulators
   ⓒ Conductors ⓓ Superconductors
2. Which of the following are materials that have a small resistance?
   ⓐ Semiconductors ⓑ Insulators
   ⓒ Conductors ⓓ Superconductors
3. A conductor is distinguished from an insulator with the same number of atoms by The number of
   ⓐ free atoms ⓑelectrons
   ⓒ free electrons ⓓ protons
4. The free positive charge distribution over the surface of two isolated spheres is shown in the diagram. Which of the following is correct for the two spheres ?
   ⓐ Both conductors ⓑ Both insulators
   ⓒ 1 conductor and 2 insulator ⓓ 1 insulator and 2 conductor



5. The figure shows the distribution of charges on the body.
   Which of the following is correct?
   ⓐ not charged ⓑ positively charged
   ⓒ negatively charged ⓓ We can't know the charge type



6. The diagram shows a sphere carrying a charge
   Which of the following is true ?
   ⓐThe body is insulator and charged by losing electrons
   ⓑ The body is conductor and charged by gaining electrons
   ⓒThe body is conductor and charged by losing electrons
   ⓓThe body is insulator and charged by gaining electrons

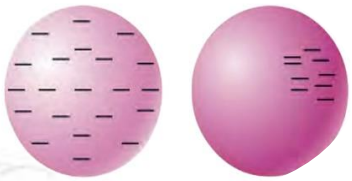


1	2

7. Which of the following explains why diamond is classified as an insulator?
   ⓐ Charges cannot move easily through diamond.
   ⓑ The number of electrons in diamond is less than the number of protons.
   ⓒ Diamond cannot be charged.
   ⓓ Electrons can be easily removed from diamond.

8. as shown in the figure the negative Charge distribution over the surface of two isolated spheres Which of the following is correct?

	Sphere A	Sphere B
A	Copper	Plastic
B	Plastic	Copper
C	Copper	Copper
D	Plastic	Plastic



A B

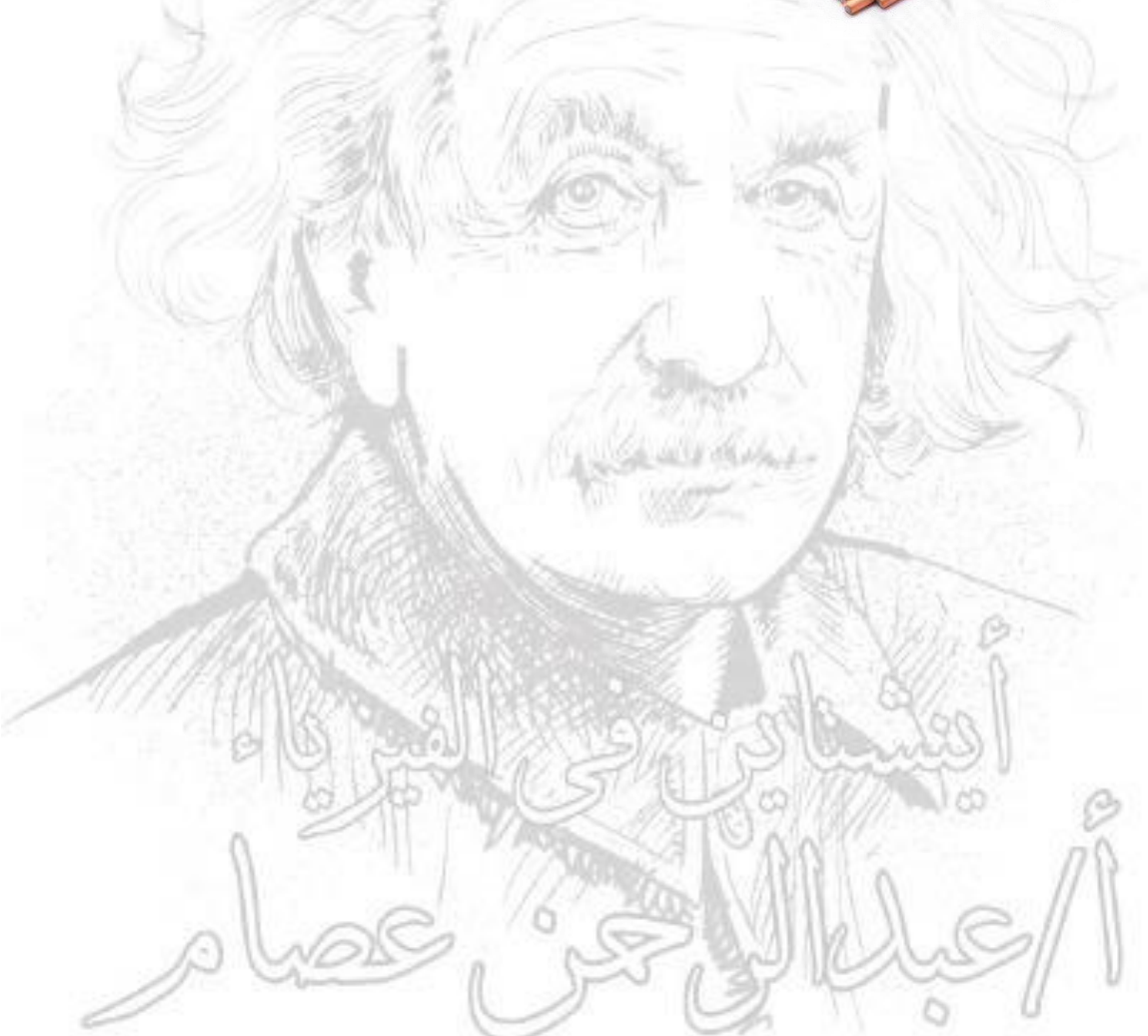
9. Which of the following explains why copper is classified as an conductor?

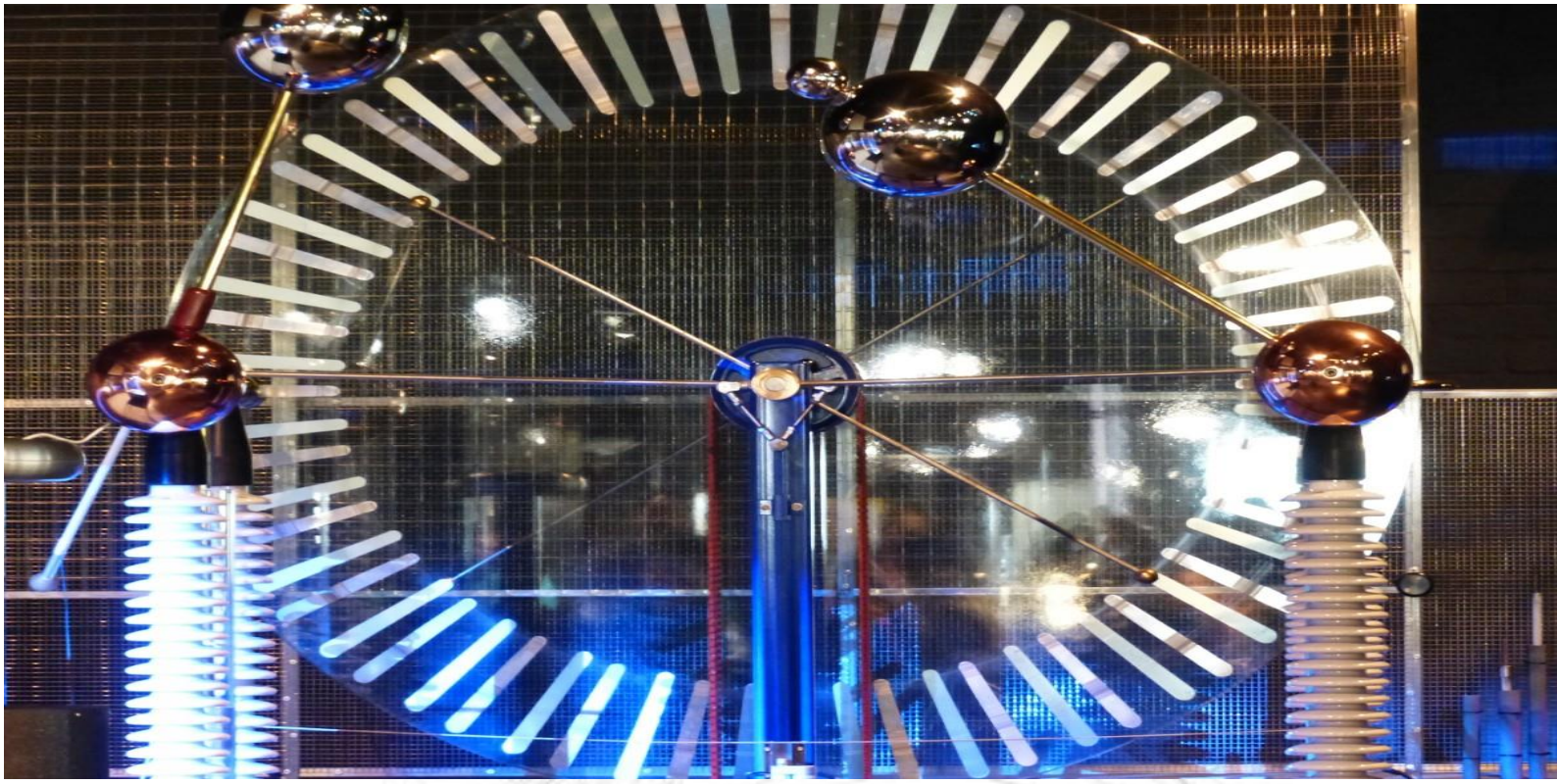
ⓐ Charges can move easily through copper.

ⓑ The number of electrons in copper is less than the number of protons.

ⓒ Copper cannot be charged.

ⓓ Electrons can be easily removed from copper.





SECTION 2

Electrostatic charging

Electrostatic charging: a process to giving a static charge to an object.

Electroscope consists of a metal knob connected by a metal stem to two thin, lightweight pieces of metal foil, called leaves, that are enclosed to eliminate air currents

Determining charge

Charging by conduction (contact):

By touching a neutral object with a charged object can result in a transfer of electrons between them.

As a result, the two objects will have the same kind of charge

NOTES :

To charge an electroscope by conduction, let a charged metal rod touch the electroscope's knob.

Bringing a negatively charged rod near a negatively charged electroscope causes the leaves to spread apart farther.

Bringing a positively charged rod near a negatively charged electroscope causes the leaves to fall closer together

Charging by induction

Without touching a charged object is approaching near to a neutral object it will cause electrons to rearrange their positions on the neutral object.

The neutral object stays neutral because there was no transfer of electrons to it or from it.

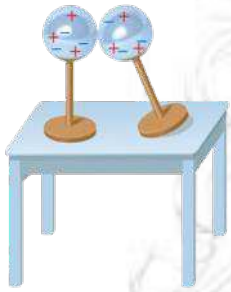
To make it charged we need to conduct it with another identical sphere or with ground.

STEPS

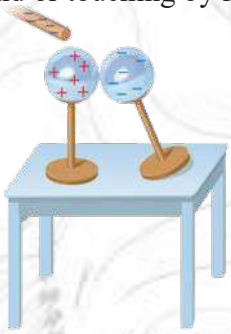
A. A neutral electroscope has an even charge distribution, and the leaves hang loosely.

B. Separation of charge is induced in the electroscope when a negatively charged rod is brought near it (Without touching) .
C. Touching the electroscope allows the charged rod to push electrons out into the hand instead of down into the leaves (Grounding) .
D. When the ground is removed from the electroscope before the rod is removed, an excess of positive charge is left on the electroscope.

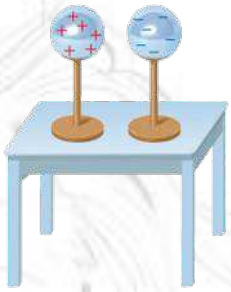
Grounding: neutralizing electrically charged objects (discharge) when objects in contact with the Earth. an electrical connection to the Earth is called a ground or touching by hand .



Neutral spheres are touching.



Both spheres are charged by induction.



The separated spheres have opposite charges.

Charging by friction: (Separation of electrons): is done by kneading material neutral with another neutral material. (Ex: Plastic with wool, glass with silk)

Notes

1. It is used to charge conductors and insulators.
2. It results in two bodies with the same amount of charge but different in type, in application of the principle of conservation of charge.

The amount of charge on both bodies increases with the number of times the kneading ncreases.

3. It is not necessary for friction to occur between two bodies in order for each of them to acquire an electrical charge, but rather it is sufficient Two different types of insulators come into contact and then separate from each other to acquire an electrical charge It occurs when we pull a strip of sticky paper from a roll of tape.

When using this method with a conductor, it must be held with insulation so that the charges formed on it are not transferred to the body and then to the ground

Questions

Check your understanding

1 Choose the correct answer:-

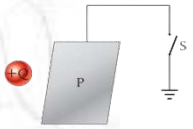
1. The figure shows charging by

ⓐ Triboelectric ⓑ conduction ⓒ Induction ⓓ Grounding

2. The figure shows charging by

ⓐ Triboelectric ⓑ conduction ⓒ Induction ⓓ Grounding

3. A metal plate is connected by a conductor to a ground through a switch. The switch is initially closed. A charge +Q is brought close to the plate without touching it, and then the switch is opened. After the switch is opened, the charge +Q is removed. What is the charge on the plate then?



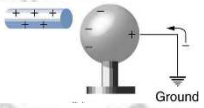
ⓐ The plate could be either positively or negatively charged
ⓑ The plate is uncharged.
ⓒ The plate is positively charged
ⓓ The plate is negatively charged.

4. You bring a negatively charged rubber rod close to a grounded conductor without touching it. Then you disconnect the ground.

What is the sign of the charge on the conductor after you remove the charged rod?

ⓐ Negative ⓑ Positive ⓒ no charge ⓓ cannot be determined

5. What is the charge of the conducting sphere if you remove away the ground connection and then remove away the charged rod.



ⓐ Negative ⓑ Positive ⓒ no charge ⓓ cannot be determined

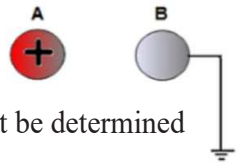
6. When you charge an object by touching it by another charged object, the process is called charging by

ⓐ Triboelectric ⓑ Conduction ⓒ Induction ⓓ Grounding

7. When you charge an object by without touching it by another charged object, the process is called charging by

ⓐ Triboelectric ⓑ Conduction ⓒ Induction ⓓ Grounding

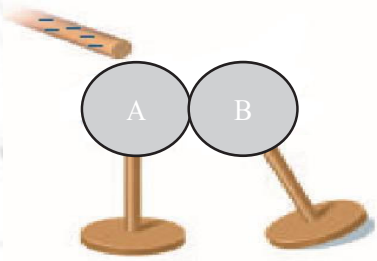
8. A positively charged sphere A is brought close without touching to a neutral sphere B as shown in the figure. Sphere B is connected with a grounded wire. What is the type of charge on sphere B?



ⓐ Negative ⓑ Positive ⓒ no charge ⓓ cannot be determined

9. Two conducting isolated neutral spheres (A, B) touching each other , a negatively charged rod isbrought close to sphere A, what is the charge of each sphere if we take sphere B away from A and then take the rod away?

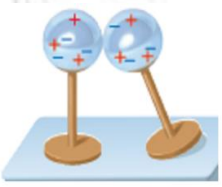
	Sphere A	Sphere B
A	Positive	Positive
B	Negative	Negative
C	Negative	Positive
D	Positive	Negative



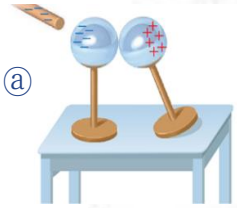
10. When two body are charged. The total charge before charging is …… The total charge after charging.

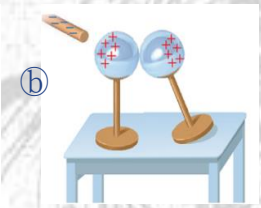
ⓐ Not equal ⓑ Equal ⓒ More than ⓓ Less than

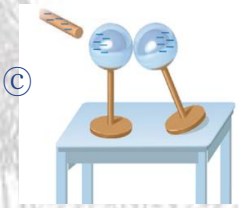
11. Two identical, neutral, and insulated metal spheres are touching, as show in the figure. If a negatively charged rod was brought close to one sphere without touching,



which of the following figures correctly shows the charges on the two spheres?

ⓐ 

ⓑ 

ⓒ 

ⓓ 

12. A charged leg was placed near the disk of an electroscope, and the two leaves of the flashlight opened, as shown in the figure.

What type of leg charge and what is the method of charging the electroscope?

	type of leg charge	method of charging
A	Negative	Induction
B	Negative	Conduction
C	Positive	Conduction
D	Positive	induction

SECTION 2

Electrostatic Force

" Alike charges repel each other while unlike charges attract each other"

Repulsive

Attractive

The forces between the two electrical charges depends on

- Type of insulating medium between the two charges
- The distance between the two charges (r)
  the force is inversely proportional to the square of the distance between charges
- The Amount of both charges
  the force is directly proportional between two charges

- We do not use the negative charge sin in law

the magnitude of electric force between two charges is calculated by Coulomb's law

$$F = \frac{kq_1q_2}{r^2}$$

where
F: electric force between charges (N)
q: first and second charge (C)
r: distance between charges (m)
ε: electric permittivity of medium (C^2/Nm^2)
k: Coulomb's constant (Nm^2/C^2)

NOTES

Electrical force is a vector quantity

Equal in magnitude and opposite in direction

Newton's third law. The force on q1 is equal in magnitude and opposite in direction to the force on q2. F12 = −F21

Newton's second law, any charged particle accelerates under influence of electric

Applications

1. A negative charge of -2.0×10^{-4} C and a positive charge of 8.0×10^{-4} C are separated by 0.30 m. What is the force between the two charges?

Solution.

Given.

$q_1 = -2.0\times10^{4}$ C

$q_2 = 8.0\times10^{-4}$ C

r = 0.30 m

$K = 9.0\times10^{9}$ N.m²/C².

Unknown.

f_e=?

We must apply coulomb's law.

$$f_e = \frac{K\,q_1\,q_2}{r^2} = \frac{9.0\times10^{9}\times2.0\times10^{-4}\times8.0\times10^{-4}}{0.30^2} = 16000\ N.$$

$$f_e = 16000 = 1.6\times10^{4}\ N.$$

2. A positive and a negative charge, each of magnitude 2.5×10^{-5} C, are separated by a distance of 15 cm. Find the force on each the particles.

Known(Given).

$q_1 = +2.5\times10^{-5}$ C.

$q_2 = -2.5\times10^{-5}$ C.

r= 15 cm = 0.15 m

K= 9.0×10^{9} N.m²/C².

Unknown.

f_e=? N

$$f_e = \frac{K\,q_1\,q_2}{r^2} = \frac{9.0\times10^{9}\times2.5\times10^{-5}\times2.5\times10^{-5}}{0.15^2} = 250N\ .$$

3. A negative charge of -6.0×10^{6} C exerts an attractive force of 65 N on a second charge that is 0.050 m away. What is the magnitude of the second charge?

Known (Given).

$q_1 = -6.0\times10^{-6}$.

F=65 N

r = 0.050 m

Unknown.

q_2 =?

$$f_e = \frac{K\, q_1\, q_2}{r^2} \qquad q_2 = \frac{f_e \times r^2}{K\, q_1}$$

$$q_2 = \frac{65 \times 0.050^2}{9.0 \times 10^9 \times 6.0 \times 10^{-6}} = 3.0 \times 10^{-6}\ C\ .$$

4. Two identical positive charges exert a repulsive force of 6.4×10^{-9} N when separated by a distance of 3.8×10^{-10} m. Calculate the charge of each.

Solution,

Known (Given).

$F_e = +6.4\times10^{-9}$ C.

$r = 3.8\times10^{-10}$ m.

$K = 9.0\times10^{9}$ N.m^2/C^2

Unknown.

$q = q_1 = q_2$ =? N.

$$f_e = \frac{K\, q^2}{r^2} \qquad q^2 = \frac{f_e \times r^2}{K} \qquad q = \sqrt{\frac{f_e \times r^2}{K}}$$

$$q = \sqrt{\frac{6.4 \times10^{-9} \times (3.8 \times10^{-10})^2}{9.0\times 10^{10}}} = 3.2 \times 10^{-19}\ C\ .$$

Check your understanding:

5. Two charges + 5.0 μC and - 6.0 μC and the force that one exerts on the other is (3.0 N). The distance between them is equal to :

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Questions

Check your understanding

1 Choose the correct answer:-

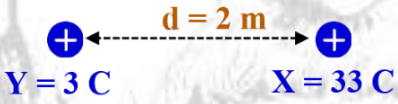
1. Two charged particles attract each other with a force F. If the charges on both are doubled, and the distance between the charges is halved then the force:

ⓐ 16F ⓑ 4F ⓒ 2F ⓓ F

2. Two small, charged objects, Q1 and Q2, are some distance d apart from each other and there is a force F between them. What is the value of the force if Q1 is increased by a factor of two, Q2 is increased by a factor of 3, and d is increased by a factor of 5 ?

ⓐ 0.20F ⓑ 0.24F ⓒ 1.2F ⓓ 0.12F

3. two charged objects are a distance 2.0 m apart. object X has a charge 33.0 C and Object Y has 3.0 C



ⓐ The magnitude of electrostatic force on X is 11 times that on Y.
ⓑ The electrostatic force on X is the same as that on Y.
ⓒ The magnitude of electrostatic force on Y is 11 times that on X
ⓓ The electrostatic force on X is the negative of that on Y.

4. Consider two protons placed near one another with no other objects close by. Which of the following is true?

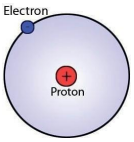
ⓐ accelerate away from each other
ⓑ remain motionless.
ⓒ accelerate toward each other.
ⓓ move away from each other at constant speed

5. The force between a 3.0μC and a 2.0μC charge is F = 10N. What is the separation distance between the two charges?

ⓐ 5.2cm ⓑ 7.3cm ⓒ 8.6cm ⓓ 9.5cm

6. An electron in a hydrogen atom experiences a Coulomb force, F = 85.2 nN, as it goesin a circular orbit around the central proton.

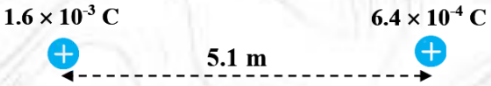
How far away is the electron from the proton:



ⓐ 0.052 nm ⓑ 0.35 nm ⓒ 27 mm ⓓ 52 μm

7. Two charges of 1.6×10^{-3} C and 6.4×10^{-4} C are a distance of 5.1 m apart.

What is the magnitude of the force (in N) acting between them?



ⓐ 120N ⓑ 35N ⓒ 290N ⓓ 354N

8. Two-point charges (+ q) and (- q) have the same magnitude and the distance between them is (9.0 cm), if the electrostatic force between the two charges is (5.0 N). What is the value of each charge?

ⓐ 7.1 nc ⓑ 7.1 µc ⓒ 2.1 nc ⓓ 2.1 µc

9. plastic ball of charge -5 nC is held 2 cm above a glass ball of charge +5 nC at rest. The mass of a glass ball must be :

plastic ball

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glass ball

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10. Two charges $q_1 = +3\mu C$ and $q_2 = +2\ \mu C$ are separated 3 cm from each other as Find the electric force between the two charges?

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11. A negative charge of $-6\ \mu C$ exerts an attractive force of 65 N on a second charge that is 0.050 m away. What is the magnitude of the second charge?

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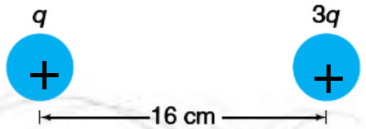
12. Two positively charged spheres, one with three times the charge of the other. The spheres are 16 cm apart, and the force between them is 0.28 N. What are the charges on the two spheres?



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13. Two charged spheres are 8.00 cm apart. They are moved closer to each other by enough that the force on each of them increases four times. How far apart are they now?

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14. Two identically charged particles separated by a distance of 1.00 m repel each other with a force of1.00 N. What is the magnitude of the charges?

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15. Two charged objects experience a mutual repulsive force of 0.100 N. If the charge of one of the objects is reduced by half and the distance separating the objects is doubled, what is the new force?

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(Superposition Principle (The sum of the forces acting on a point charge

In the case of multiple charges affecting forces on a particular electric charge.
We calculate the sum of the forces acting on the point charge:

1. The two forces on one straightness and in the same direction

   (The result is the sum of their amounts in the same direction)

   $$Fnet = F_1 + F_2$$

2. The two forces on one straightness and in the opposite direction

   (The result is the minus of their amounts and in the direction of the great force)

   $$Fnet = F_{great} - F_{less}$$

3. The two forces are perpendicular We apply the Pythagorean law

   $$Fnet = \sqrt{{F_x}^2 + {F_y}^2}$$

   $$\theta = tan^{-1}(\frac{F_y}{F_x})$$

NOTES

Coulomb's Law in two Dimensions.

1. Sphere A, with a charge of +6.0 μC, is located near another charged sphere, B. Sphere B has a charge of -3.0 μC and is located 4.0 cm to the right of A.
   a. What is the force of sphere B on sphere A?
   b. A third sphere, C with a +1.5 μC charge, is added. If it is located 3.0 cm directly beneath A, what is the new net force on sphere A?

Solution.

Known (Given).

$q_A = q_1 = +6.0\ \mu C = +6.0\times10^{-6} C$

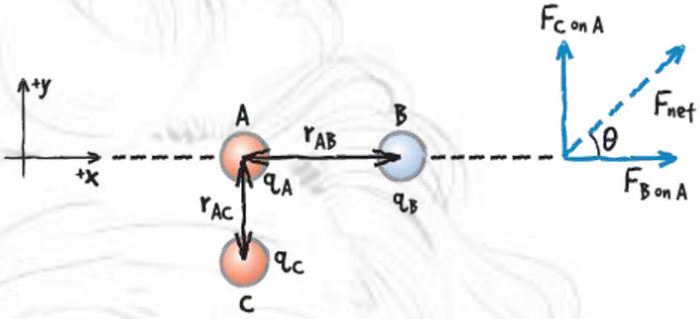
$q_B = q_2 = -3.0\ \mu C = -3.0\times10^{-6} C$

$q_c = q_3 = +1.5\ \mu C = +1.5\times10^{-6} C$

$r_{AB} = r_1 = 4.0\ cm = 4.0\times10^{-2} m$

$r_{AC} = 3.0\ cm = 3.0\times10^{-2} m$

$K = 9.0\times10^{9}\ N.m^2/C^2$.



Unknown (Not Given).

a. $F_{BA} = ?$

b. $F_{CA} = ?$

c. F_{net}

$$F_{BA} = \frac{K\,q_1\,q_2}{r_1^2} = \frac{9.0\times10^{9}\times6.0\times10^{-6}\times3.0\times10^{-6}}{(4.0\times10^{-2})^2} = 1.0\times10^{2}\ N\ .$$

Because spheres A and B have unlike charges, the force of B on A is to the right.

$$F_{CA} = \frac{K\,q_3\times q_1}{{r_{AC}}^2} = \frac{9.0\times10^{9}\ \times1.5\times10^{-6}\ \times6.0\times10^{-6}}{(3.0\times10^{-2})^2} = 9.0\times10^{1}\ N$$

Spheres A and C have like charges, which repel. The force of C on A is upward.

Find the vector sum of $F_{B\ on\ A}$ and $F_{C\ on\ A}$ to find F_{net} on sphere A.

$$F_{net} = \sqrt{(F_{(B\ on\ A)})^2 + (F_{C\ on\ A})^2} = \sqrt{(1.0\times10^{2})^2 + (9.0\times10^{1})^2} = 130\ N.$$

A positive charge of 3.0 μC is pulled on by two negative charges.one negative charge, -2.0 μC is 0.050 m to the west, and the other, -4.0 μC, is 0.030 m to the east.

What net force is exerted on the positive charge?

Solution.

Known physical quantities (Given).

$q_1 = -2.0\ \mu C = -2.0\times10^{-6} C$.

$q_2 = +3.0\ \mu C = +3.0\times10^{-6} C$

$q_3 = -4.0\ \mu C = -4.0\times10^{-6} C$

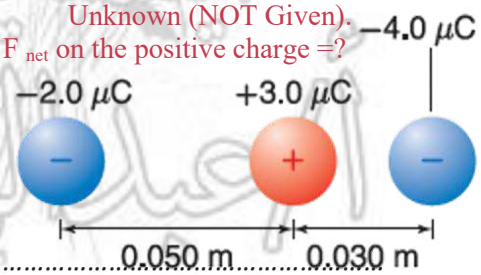
$r_{1,2}$ 0.050 m

$r_{2,3} = 0.030$ m

Apply coulomb's Law.

Unknown (NOT Given).

F_{net} on the positive charge =?



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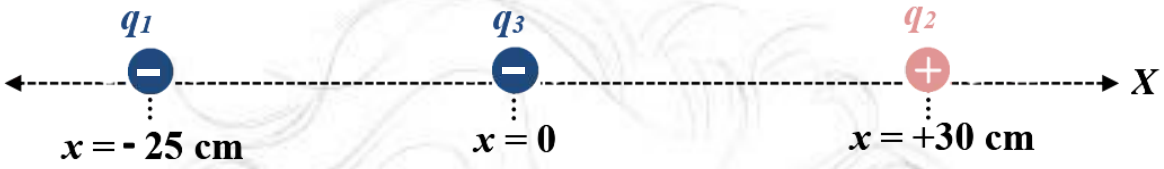
Check your understanding:

2. A particle ($q_1 = -15.0\ \mu C$) is located on the x axis at the point $x = -25.0$ cm, and a second particle ($q_2 = +45.0\ \mu C$) is placed on the x- axis at $x = +30.0$ cm. What is the magnitude of the total electrostatic force on a third particle ($q_3 = -3.50\ \mu C$) placed at the origin ($x = 0$) ?



3. Three point charges are placed on the x-axis as shown. Assume that $Q_1 = 2.40\ \mu C$, $Q_2 = -Q_1$, and $Q_3 = Q_1$. The coordinates of the point charges are $x_1 = -0.100$ m , $x_2 = 0.120$ m, $x_3 = 0.300$ m. What is the force (in N) on Q_2 ?