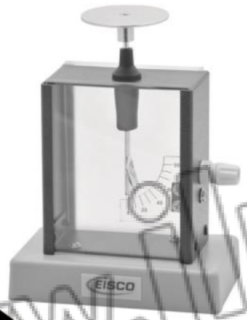


UNIT 13

ELECTROSTATICS

13.1 PRODUCTION OF ELECTRIC CHARGES

LONG QUESTIONS

Q.1 What is electrostatic? How electric charges be produced? Explain it with experiments.
OR How can you show by simple experiments that there are two types of electric charges? *(K.B+U.B+A.B)* **(Review Question 13.1)**

Ans:

ELECTROSTATICS

Definition:

"Study of charges at rest is called electrostatics or static electricity".

Production of Electric Charges:

We can produce electric charge by rubbing a neutral body with another neutral body. The following activates show that we can produce two types of electric charges through the process of rubbing.

Experiment 1:

Take a plastic rod. Rub it with fur and suspend it horizontally by a silk thread. Now take another plastic rod and rub it with fur and bring near to the suspended rod.

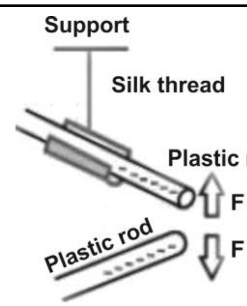


Figure: Like Charges Repel Each Other

Observation:

We will observe that both the rods will repel each other. It means during the rubbing both the rods were charged both rods have same charge.

Experiment 2:

Now take a glass rod and rub it with silk and suspend it horizontally. When we bring the plastic rod rubbed with fur near to the suspended glass rod.

Figure: Unlike charges attract each other

Observation:

We observe that both the rods attract each other. In the first activity, both rods are plastic and both of them have been rubbed with fur. Therefore, we assume that charge on both rods will be off same kind. In the second activity, rods are unlike and their attraction implies that charge on the two rods are not of the same kind but of opposite nature. These opposite charges are conventionally called positive charge and negative charge. During the process of rubbing negative charge is transferred from one object to another object from these activities we conclude that:

Conclusions:

1. **Charge is a basic property of a material body due to which it attracts or repels another object.**
2. **Friction produces two different types of charge on different material such as glass and plastic).**
3. **Like charges always repel each other.**
4. **Unlike charges always attract each other.**
5. **Repulsion is the sure test of charge on a body.**

13.1 SHORT QUESTIONS

Q.1 How can we produce a charge in neutral body? *(K.B)*

Q.2 What is electrostatics? *(K.B)* **(LHR 2013)**

Q.3 Rod cannot be charged by rubbing, if held by hand? **(Conceptual 13.8)**

Ans: **CHARGING OF A GLASS ROD**

Because glass rod is an insulator, so charge developed on it during rubbing does not flow to the ground through the hand holding it. However, iron rod is a conductor and charge developed on it during rubbing can easily flow to the ground through the hand holding it. For this reason all metal objects used in electrostatic have insulating handles or stands.

Q.4 What are the characteristics of charges? *(K.B)*

Q.5 If cat skin is rubbed with lead then which one will get positive charge?*(K.B)*

(For your information Pg. # 70)

Ans: **RUBBING OF CAT SKIN WITH LEAD**

According to the priority list of material rubbed with one another.

1. Asbestos	**2.** Glass Mica	**3.** Woollen cloth	**4.** Cat's skin
5. Lead	**6.** Silky cloth	**7.** Aluminium	**8.** Cotton cloth
9. Wood	**10.** Cooper	**11.** Rubber	**12.** Plastic

The material occurring first in the list would have positive charge and that occurring next would have negative charge. Since cat's skin is occurring first therefore it would get positive charge and lead would get negative charge.

Q.6 Do you think amount of positive charge on the glass rod after rubbing it with silk cloth will be equal to the amount of negative charge on the silk? Explain. *(K.B+U.B+A.B)* **(Self-Assessment Pg. # 70)**

Ans: **AMOUNT OF CHARGE**

When a glass rod is rubbed with silk cloth then due to friction heat is generated. The electrons of glass rod are loosely bounded, they absorb heat and jump on the silk cloth and hence, glass rod gets positive charge. For example, if it loses two electrons then the same is received by silk cloth. Therefore,

Charge on glass rod $= + 2\times1.6\times10^{-19}$ C

$= +3.2 \times 10^{-19}$ C

Charge on silk cloth $= -\ 2 \times 1.6 \times 10^{-19}$ C

$= -3.2 \times 10^{-19}$ C

Conclusion:

> **Hence, amount of positive charge on the glass rod after rubbing it with silk cloth will be equal to the amount of negative charge on the silk.**

Q.7 What would happen if a neutral glass rod is brought near a positively charged glass rod?*(K.B)*

Ans: **NEUTRAL GLASS ROD**

When a neutral glass rod is brought near a positively charged glass rod, then the electrons of the neutral glass rod will be attracted by the positively charged glass rod. Due to this attraction, near end of the neutral glass rod will become negative and other end will become positive.

13.1 MULTIPLE CHOICE QUESTIONS

1. Study of charges at rest is called: *(K.B)*
(A) Electrostatics (B) Magnetism
(C) Electrochemistry (D) Electric Current

2. An insulating rod is charged positively by rubbing. This is due to: *(K.B+U.B)*
(A) Deficiency of protons (B) Excess of protons
(C) Deficiency of electrons (D) Excess of electrons

3. When an insulating rod is charged negatively, this is due to? *(K.B+U.B)*
(A) Deficiency of protons (B) Excess of protons
(C) Deficiency of electrons (D) Excess of electrons

4. If we run a plastic comb through hair and then bring it near shell pieces of paper. The comb will: *(K.B+A.B)*
(A) Attract them (B) Repel them
(C) Both a and b (D) None of these

5. Electric charges can be produced by rubbing a neutral body with: *(K.B)*
(A) Charged body (B) Another neutral body
(C) Both a and b (D) None of these

6. SI unit of electric charge is*(K.B)*
(A) Coulomb (B) Ampere
(C) Volt (D) Watt

7 A positive charge: *(K.B)*
(A) Attract other positive (B) Repel other positive charge
(C) Attract the natural charge (D) Repels a neutral charge

8. An object gain excess negative charge after being rubbed against another object: *(K.B)*
(A) Neutral (B) Negative charged
(C) Positively charge (D) Either a, b or c

9. A body can be charged by: *(K.B)*
(A) Rubbing with another body (B) Conduction
(C) Electrostatic induction (D) All of these

10. How many type charges exist only? *(K.B)* **(GRW 2013)**
(A) One (B) Two
(C) Three (D) Four

11. When a glass rod is rubbed with a silk cloth, then? *(K.B)*
(A) Glass rod acquires negative charge while silk acquires positive charge
(B) Glass rod acquires positive charge while silk acquires negative charge
(C) Both glass rod and silk acquire negative charge
(D) Both glass rod and silk acquire positive charge

12. If a glass rod is rubbed with a silk cloth, it receives charge by the process of: *(K.B)*
(A) Heating (B) Separation of charge
(C) Rubbing (D) Electric force

13. Which one of the following statements is correct? *(K.B)*
(A) Similar charges attract each other
(B) Similar charges repel each other
(C) Similar charges attract and repel each other
(D) Similar charges neither attract nor repel each other

14 Which one of the following statements is correct? *(K.B)*
(A) Opposite charges attract each other
(B) Opposite charges repel each other
(C) Opposite charges attract and repel each other
(D) Opposite charges neither attract nor repel each other

15. Metals are good conductors of electricity, because they have: *(K.B)*
(A) Large number of bounded electrons (B) Small number of bounded electrons
(C) Large number of free electrons (D) Small number of free electrons

16. Free electrons are: *(K.B)*
(A) Tightly bound (B) Fixed
(C) Loosely bound (D) Strongly fixed

17. The number of electrons in one coulomb charge is equal to: *(K.B+U.B)*
(A) 6.25×10^{18} (B) 1.6×10^{-19}
(C) Zero (D) 6.2×10^{21}

18. Like charges always. *(K.B)*
(A) Attract each other (B) Repel each other
(C) Attract and repel each other (D) None of these

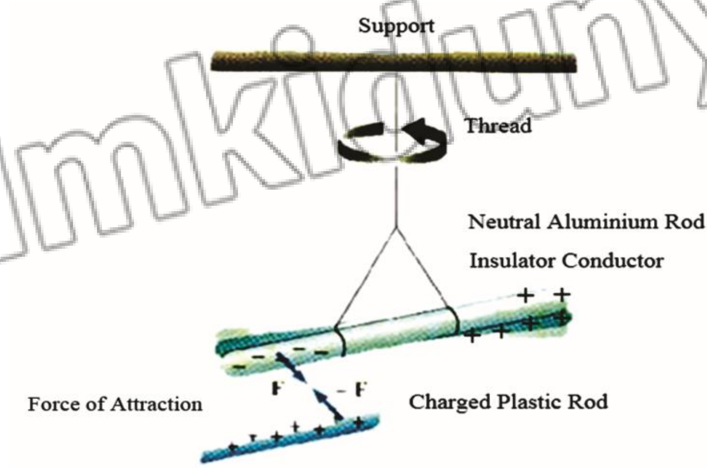
13.2 ELECTROSTATIC INDUCTION

LONG QUESTION

Q.1 Describe the method of charging bodies by electrostatic induction. *(K.B+U.B+A.B)*
(Review Question 13.2)

Ans: **ELECTROSTATIC INDUCTION**

Definition:
In the presence of a charged body, an insulated conductor develops positive charge at one end and negative charge at the other end. This process is called the electrostatic induction.



Whenever a charged body is brought close to an insulator conductor, the near end of the conductor develops an unlike charge while the far end of the conductor develops a like charge. This separation of charges is called electrostatic induction.

Experiment 1:

If we bring charged plastic rod near suspended neutral aluminium rod, both rods attract each other.

This attraction between the charged and uncharged rods shows as if both rods have unlike charges. But this is not true. Charged plastic rod produces displacement of positive and negative charges on the neutral aluminium rod which is the cause of attraction between them. But total charge on aluminium rod is still zero. It implies that attraction is not the sure test of charge on a body.

It also shows that electrostatic induction is another method of charging a body.

Method of Charging a Bodies by Electrostatic Induction:

Experiment 2:

Bring two metal spheres A and B and fix them on insulated stands, such that they touch each other. Now bring a positively charged rod near sphere A. Rod will attract negative charge towards it and repel positive charge away from it. Negative charge will appear on the left surface of the sphere A which is close to the rod.

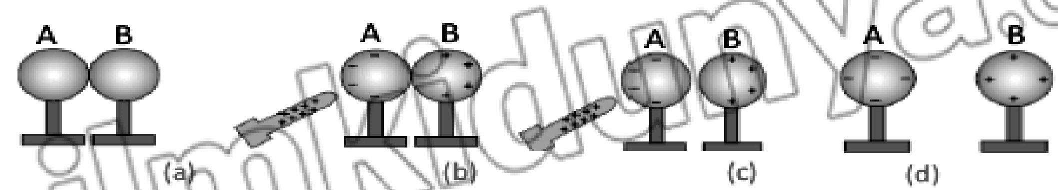


Figure: Electrostatic Induction

While positive charge will appear on the right surface of the sphere B. Now separate the spheres while the rod is still near the sphere A. Now if you test the two spheres, you will find that the two spheres, will be oppositely charged. After removing the rod, the charges are uniformly distributed over the surfaces of the spheres.

Conclusion:

In this process, an equal and opposite charges appear on each metal sphere. This is called charging by induction.

SHORT QUESTIONS

Q.1 What is meant by electrostatic induction, for which purpose it is used? *(K.B+A.B)*
(GRW 2013, LHR 2016)

Q.2 How electric charge is produced in bodies by friction? *(K.B)*

Ans: **CHARGING BY FRICTION**

When we rub two bodies, we provide external force by rubbing. Then the loosely bound electrons in one body are transferred to the other body. As electrons carry negative charge, therefore, a negative charge is developed on the body which gets electrons and positive charge is developed on that body which loses electrons.

Q.3 Where electrostatic induction is used? *(A.B)*

OR What are the applications of electrostatic induction?

Ans: **APPLICATION OF ELECTROSTATIC INDUCTION**

Electrostatic is used in everyday lives which includes:

- Photocopying
- Car painting
- Extracting dust from chimneys of industrial machinery.

Q.4 What is electrostatic precipitators? *(Conceptual Base+ A.B)*

Ans: Electrostatic precipitators are fitted to the chimneys of some power stations and factories. They reduce pollution by removing tiny bits of ash from the waste gases. Inside the chamber of a precipitator, the ash is charged by wires, and then attracted to the metal plates by an opposite charge. When shaken from the plates, the ash collects in the tray at the bottom.

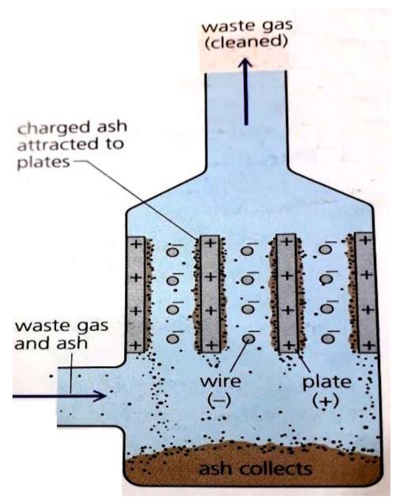


Fig. Electrostatic Precipitators

Q.5 What is induced charges? *(Conceptual+A.B)*

Ans: Charges that 'appear' on an uncharged object because of a charged object nearby are called induced charges. In the diagram below, a metal sphere is being charged by induction. The sphere ends up with an opposite charge to that on the rod, which never actually touches the sphere.

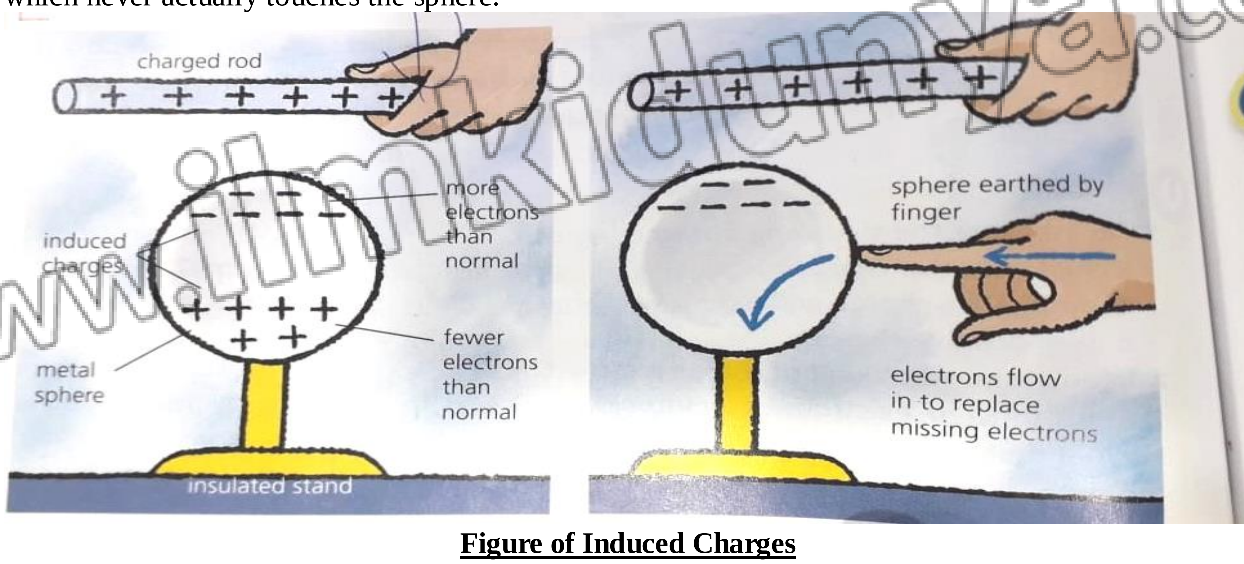


Figure of Induced Charges

Q.6 How photocopier works? *(Conceptual+A.B)*

Ans: Photocopier work using the principle shown in the diagrams below.

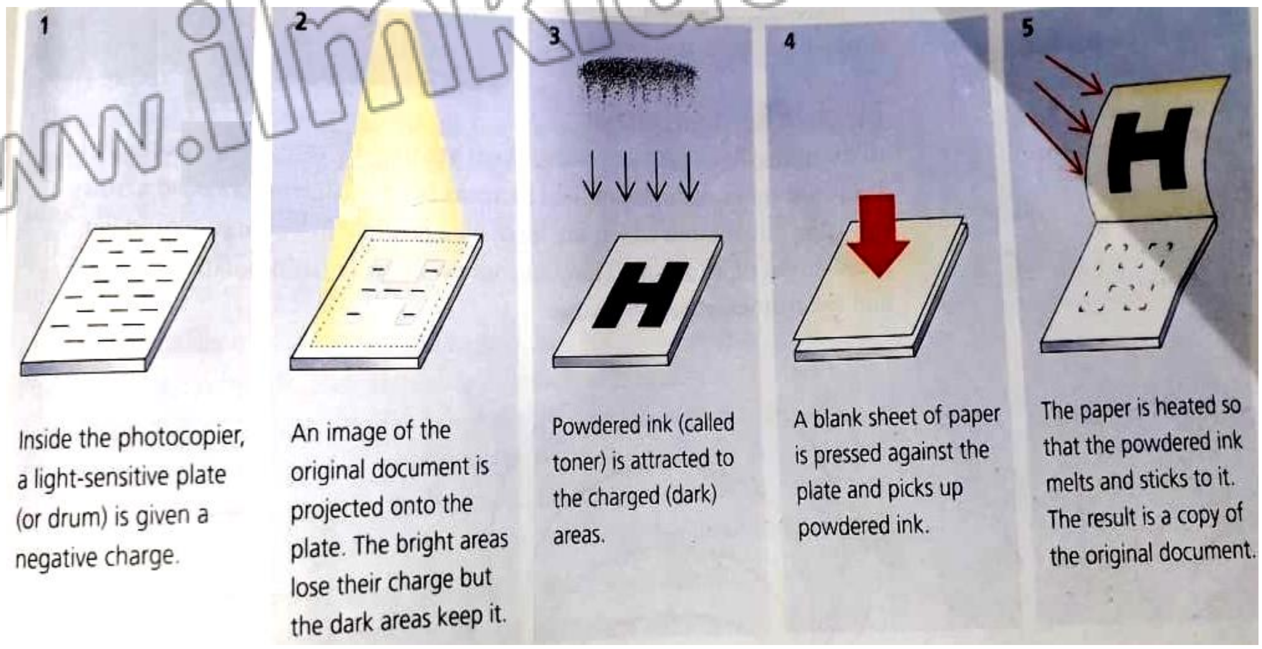


Figure of Photocopier

Q.7 How does electrostatic induction differ from charging by friction? *(K.B+U.B)*

(Review Question 13.3)

Ans: **DIFFERENT METHODS OF CHARGGING**

During the process of charging by friction, we rub a neutral body with another neutral body. But in the process of electrostatic induction. We charge a conductor without making any contact with the charging body.

Q.8 An charge rod attracts pieces of paper. After a while these pieces fly away! Why? *(K.B+U.B)* **(Conceptual 13.1)**

Ans: **ELECTRIFIED ROD AND PIECES OF PAPERS**

When a glass rod is rubbed with a silk cloth, it is positively charged. This electrified rod attracts pieces of paper. When the pieces of paper touch the rod, they give up some electrons to the glass rod and become positively charged. They are then flown away by the rod due to force of repulsion form the positive charge remaining on the rod.

Q.9 Why attraction is not the sure test for detecting the presence of charge on a body? *(K.B+U.B)*

Ans: ***Given on Page # 156(Experiment No.1)***

13.2 MULTIPLE CHOICE QUESTIONS

1. **In the presence of a charged body an insulated conductor develops positive charge at one end and negative charges at other end, this process is called the. *(K.B)***

(A) Electrostatic induction (B) Conduction
(C) Friction (D) All of these

13.3 ELECTROSCOPE

LONG QUESTION

Q.1 What is gold leaf electroscope? Discuss its working principle with a label diagram. ***(K.B+U.B+A.B)***

OR Describe a gold leaf electroscope. By using an electroscope, how can we find the
(i) Presence of charge on a body **(Review 13.6)**
(ii) The nature of the charge on a body **(Review 13.7)**
(iii) Whether a body is an insulator or a conductor **(LHR 2015)**

OR Suppose you have a glass rod which becomes positively charged when you rub it with wool. Describe how you would charge the electroscope. **(Review 13.5)**

Ans: **GOLD LEAF ELECTROSCOPE**

Definition:

The gold leaf electroscope is a sensitive instrument for detecting charges, nature of charges and identifying conductor and insulator.

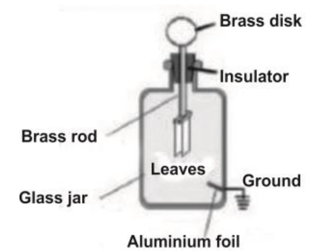


Figure: Gold Leaf Electroscope

Construction & Working:

It consists of a brass rod with a brass disk at the top and two thin leaves of gold foil hanging at the bottom. The rod passes through an insulator that keeps the rod in place. The whole assembly is filled in a glass jar. Charges can move freely from the disk to the leaves through the rod.

A thin aluminum foil is attached on the lower portion of the inside of the jar. Usually, the aluminum foil is grounded by connecting a copper wire. This protects the leaves from the external electrical disturbances.

(i) Detecting the Presence of Charge:

In order to detect the presence of charge on anybody, bring the body near the disk of an uncharged electroscope. If the body is neutral there will be no deflection of the leaves.

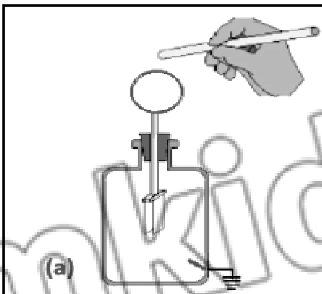


Figure: Uncharged Body

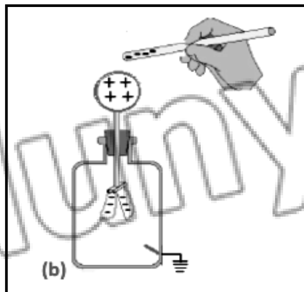


Figure: Charged Body

But if the body is positively or negatively charged, the leaves of the electroscope diverge. For example, if the body is negatively charged then due to electrostatic induction, positive charge will appear on the disk while negative charge will appear on the leaves.

The leaves of electroscope repel each other and diverge because each leave gets similar charge. The divergence of leaves will depend on the amount of charge.

Conclusion:

The divergence of leaves show that the body is charged.

Charging the Electroscope by Electrostatic Induction:

Electroscope can be charged by the process of electrostatic induction. In order to produce positive charge on the electroscope, bring a negatively charged body near the disk of the electroscope. Positive charge will appear on the disk of the electroscope while negative charges will shift to the leaves. Now connect the disk of electroscope to the earthed aluminum foil by a conducting wire.

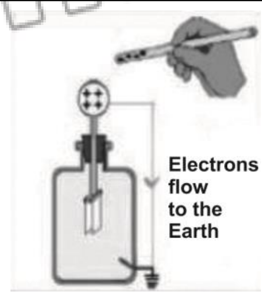


Figure: Charging the Electroscope Positively

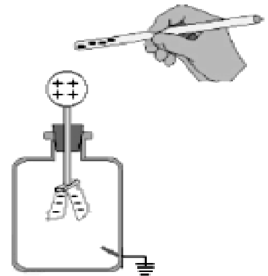


Figure: Charging the Electroscope Positively

Charge of the leaves will flow to the Earth through the wire. Now if we first break the Earth connection and then remove the rod, the electroscope will be left with positive charge.

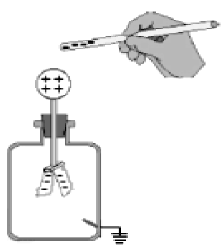


Figure: Charging the Electroscope Positively

Charging the Electroscope by Conduction:

Electroscope can also be charged by the process of conduction. Touch a negatively charged rod with the disk of a neutral electroscope. Negative charge from the rod will transfer to the electroscope and will cause its leaves to diverge.

(ii) Detecting the Type of Charge:

For the detection of type of charge on a body, electroscope is first charged either positively or negatively. Suppose the electroscope is positively charged.

Figure: Charged Electroscope

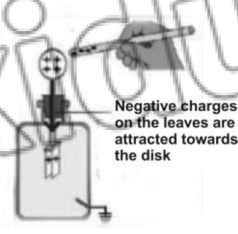


Figure: Detecting –ve Charge

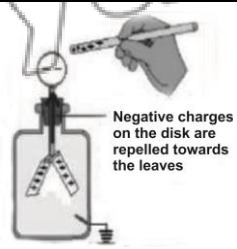


Figure: Detecting +ve Charge

Now in order to detect the type of charge on a body, bring the charged body near the disk of the positively charged electroscope.

Conclusion:

If the divergence of the leaves increases, the body carries positive charge. On the other hand if the divergence decreases, the body has negative charge.

(iii) Identifying Conductors and Insulators:

Electroscope can also be used to distinguish between insulators and conductors. Touch the disk of a charged electroscope with material under test. If the leaves collapse from their diverged position the body would be a good conductor. If there is no change in the divergence of the leaves, it will show that the body under test is an insulator.

13.3 SHORT QUESTION

Q.1 How electroscope can be charged? *(K. B+U.B)*

Ans: **CHARGING OF ELECTROSCOPE**

Electroscope can be charge by the process of electrostatic induction. It can also be charged by process of conduction.

Q.2 What is electroscope? Give its construction. *(K.B)*

Ans: ***Given on Page # 160***

Q.3 How can we detect with electroscope that body is conductor or insulator? *(K.B+U.B+A.B)* **(GRW 2014, LHR 2016).**

Ans: ***Given on Page # 161***

Q.4 How much negative charge has been removed from a positively charged electroscope if it has a charge of 7.5 x 10^{-11}C? *(U.B)* **(Conceptual 13.2)**

Ans: **REMOVAL OF NEGATIVE CHARGE**

A charge of -75×10^{-11} C has been removed from a positively charged electroscope which has a charge of 7.5×10^{-11}C.

Q.5 Why leaves of charged electroscope diverge if we touch its disk with a metal rod but they do not diverge if we touch the disk with a rubber rod? *(A.B+C.B+U.B)*

(Point to ponder Pg. # 74)

Ans: **DIVERGENCE OF LEAVES**

If we touch the disk of a charged electroscope with a conductor, electrons will flow from electroscope of the ground or from ground to the electroscope. It depends upon the type charge on the disk of the electroscope. Due to this transfer of charges, divergence of leaves will decrease or increase accordingly. As in case of an insulator, there is no any flow of charges (as insulators are bad conductors), so there is not any change in the position of leaves of the electroscope.

Q.6 In a dry day, if we walk in a carpeted room and then touch some conductor, we will get a small electric shock! Can you tell why does it happen? *(C.B)*

(Point to ponder Pg. # 74)

Ans: **ELECTRIC SHOCK**

It is caused by static electric charges accumulated on our body due to friction while walking on a carpet.

Q.7 Show diagrammatically how like charges repel and unlike charges attract?(U.B)

(For your information Pg. # 71)

Ans: **CHARGES**

Figure: Like Charges Repel

Figure: Unlike Charges Attract

Q.8 Why we get more electric shock in winter as compared to in summer? *(C.B+A.B)*

Ans: Because in winter the air is dry and do not have humidity that is why our body accumulate electrostatic charges and when we touch a conductor we get electric shock because our body discharge. But in summer air has a lot of humidity so our body continuous discharge.

13.3 MULTIPLE CHOICE QUESTIONS

1. **Electroscope is an instrument used for. *(A.B)*** **(LHR 2015)**
   (A) Detecting presence of charge (B) To detect the type of charges
   (C) To identify conductor and insulator (D) All of these
2. **Electroscope can be charge by the process. *(K.B)***
   (A) Magnetism (B) Internal reflection
   (C) Electrostatic induction (D) Electromagnetic tension

13.4 COULOMB'S LAW

LONG QUESTION

Q.1 Explain Coulomb's law of electrostatic and write its mathematical form. *(K.B+U.B+A.B)* **(Review 13.8)**

Ans: <u>**COULOMB'S LAW**</u>

<u>Introduction</u>:
In 1785, a French scientist Charles Coulomb established the fundamental law of electric force between two stationary charged particles.

<u>Statement</u>:
"The force of attraction or repulsion between two point charges is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them**"**.

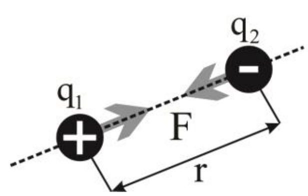


Figure: <u>**Attraction between Opposite Charges**</u>

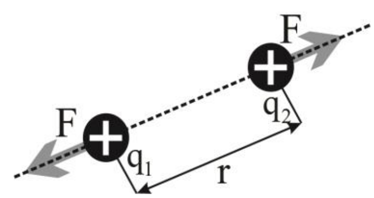


Figure: <u>**Repulsion between Similar Charges**</u>

<u>Mathematically</u>:

$$F \propto q_1 q_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$F \propto \frac{1}{r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Combining equations (i) and (ii) we get

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = k\frac{q_1 q_2}{r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Equation (iii) is known as coulomb's law.
Where **F** is the force between the two charges and is called the coulomb force, $\mathbf{q_1}$ and $\mathbf{q_2}$ are the quantities of two charges and **r** is the distance between the centre of two charges. **K** is the constant of proportionality.

<u>Dependence of Value of K</u>:
The value of **K** depends upon the medium between the two charges. Now if the medium between the two charges is air then the value of **K** in **SI** units will be $\mathbf{9 \times 10^9\ Nm^2C^{-2}}$.

Point Charges

Definition:

"Point charges are the charges whose sizes are very smallest compared to the distance between them".

Validity of Coulomb's Law:

Coulomb's law is true only for point and stationary charges.

13.4 SHORT QUESTIONS

Q.1 State the Coulomb's law. *(K.B+U.B+A.B)* **(GRW 2013(R), LHR 2015)**

Ans: ***Given on Page # 162***

Q.2 What is the SI unit of charge?(K.B) **(For your Information Pg. # 74)**

Ans: **SI UNIT OF CHARGE**

The SI unit of charge is Coulomb (C). It is equal to the charge of 6.25×10^{18} electrons. This is very big unit. Usually, charge is measured in micro coulomb is equal to 10^{-6} C.

Q.3 What is meant by point charges? *(K.B)* **(LHR 2015)**

Ans: ***Given on Page # 163***

Q.4 What will happen to Coulomb's force, if the distance between two point charges becomes double? *(U.B+A.B)* **(Quick quiz Pg. # 76)**

Ans: **COULOMB'S FORCE WHEN DISTANCE IS DOUBLED**

According to coulomb's law

$$F = k\frac{q_1q_2}{r^2}$$

When r = 2r

$$F' = k\frac{q_1q_2}{(2r)^2}$$

$$F' = k\frac{q_1q_2}{4r^2}$$

Then

$$F' = \frac{1}{4}k\frac{q_1q_2}{r^2}$$

$$F' = \frac{F}{4}$$

Result:

Thus if the distance between two point charges is doubled, the coulomb's force between them will be one fourth of the original force.

Q.5 In which direction Coulomb's force act between the two charges? *(K.B)*

Ans: **DIRECTION OF COULOM'S FORCE**

The Coulomb's forces have equal magnitude but always act in opposite directions between two similar charges.

Q.6 Suppose two spheres are positively charged. If charge on one of the sphere is doubled then what will be the electrostatic force of attraction between them and what will be the nature of the force? *(U.B+A.B)*

Ans: **ELECTROSTATIC FORCE**

According to coulomb's law

$$F = \frac{kq_1 \times q_2}{r^2}$$

Put $q_2 = 2q_2$

$$F' = 2F$$

Result:

$$F' = \frac{kq_1 \times 2q_2}{r^2}$$

$$F' = 2 \times \frac{kq_1 \times q_2}{r^2}$$

Hence, electrostatic force between the charges is two time the original electrostatic force. Since both the charges are positive therefore electrostatic force between them is force of repulsion.

13.4 MULTIPLE CHOICE QUESTIONS

1. **Who established fundamental law of electric force between two stationary charged particles? *(K.B)***
   (A) Planks (B) Faraday
   (C) Quantum (D) Coulomb
2. **According to Coulomb's law: *(U.B)***
   (A) $F=K\frac{q_1 r^2}{q_2}$ (B) $F=\frac{kr_1 r_2}{(q)^2}$
   (C) $F=\frac{kq_1 q_2}{r^2}$ (D) $F=k\frac{q_1 q_2}{r}$
3. **K is constant of proportionality given by *(K.B+U.B)***
   (A) $K=\frac{1}{4\pi \in_o}$ (B) $K=\frac{\in}{4\pi}$
   (C) $K=\frac{4\pi}{\in_o}$ (D) None of these
4. **SI unit of K is: *(K.B)***
   (A) Nm^2C (B) Nm^2C^{-2}
   (C) $N^2m^2C^{-1}$ (D) None of these
5. **The value of K is *(K.B)*** **(LHR 2013)**
   (A) $8.85 \times 10^9\ Nm^2C^{-2}$ (B) $9 \times 10^9\ Nm^2C^{-2}$
   (C) $6.67 \times 10^9\ Nm^2C^{-2}$ (D) None of these
6. **Force of attraction or repulsion acts between: *(K.B)***
   (A) Two charged bodies (B) Neutral bodies
   (C) Non charged bodies (D) All of these
7. **The value of Coulomb's constant K depends upon *(K.B)***
   (A) The system of units used
   (B) Medium between the charges
   (C) Quantity of the charges
   (D) The system of units and the medium between the charges
8. **If the distance between the two charged bodies is halved, the force between them becomes *(U.B)***
   (A) Doubled (B) Half
   (C) Four times (D) One half

9. If the distance between two charges is doubled, the electric force between them will become *(U.B)*

(A) Four times (B) Twice
(C) Half (D) One fourth

10. Electric charge of 100μC is 13 m apart from another charge 16.9μC. The force between them in Newton is *(U.B+A.B)*

(A) 9×10^7 (B) 0.09
(C) 90 (D) 9×10^5

11. The electric force of repulsion between two electrons at a distance of 1 m is *(U.B+A.B)*

(A) 1.8 N (B) 1.5×10^{-9}N
(C) 2.30×10^{-27}N (D) 2.30×10^{-27}N

12. What will be the electrostatic force between two charges each of one coulomb separated by 1m? *(U.B+A.B)*

(A) 8.85 x 10^9 N (B) 9 x 10^9 N
(C) 6.67 x 10^9 N (D) None of these

13. How much is the gravitational force which the Earth exerts on a billion kilogram object on the sea level? *(K.B+U.B)*

(A) 8.85 x 10^9 N (B) 9 x 10^9 N
(C) 6.67 x 10^9 N (D) None of these

EXAMPLE 13.1

Two bodies are oppositely charged with 500 μC and 100 μC charge. Find the force between the two charges if the distance between them in air is 0.5m. (U.B, A.B)

Solution:

Given Data:

$q_1 = 500\ \mu C$

$q_2 = 100\ \mu C$

$r = 0.5m$

To Find:

F =?

Formula:

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

Calculations:

$$F = \frac{9\times10^9\times500\times10^{-6}\times100\times10^{-6}}{(0.5)^2}$$

Putting the values from given data in the formula.

F = 1800 N

Result:

Hence, coulomb's force between the charges is 0.2N. Since both charges are positive therefore nature of force is repulsive.

13.5 ELECTRIC FIELD AND ELECTRIC FIELD INTENSITY

LONG QUESTION

Q.1 What is meant by electric field and electric intensity? Find the electric intensity due to point charge. ***(K.B+U.B+A.B)*** **(Review Question 13.9)(GRW 2014, LHR 2014)**

Ans:

ELECTRIC FIELD

Definition:

"The region of space surrounding the charge q in which it exerts a force on the charge q_0 is known as electric field of the charge q."

OR

"The electric field is a region around a charge in which it exerts electrostatic force on another charges."

Explanation:

According to Coulomb's law if a unit positive charge q_o (call it the test charge) is brought near a charge q (call it the field charge) placed in space, the charge q_o will experience a force. The value of this force would depend upon the distance between the two charges. If the charge q_o is moved away form q, this force would decrease till at a large distance the force would practically reduce to zero. Now the charge q_o is out of the influence of charge q.

ELECTRIC FIELD INTENSITY

Definition:

"The strength of electric field at any point in space is known as electric field intensity"

OR

"The electric field intensity at any point is defined as the force acting on a unit positive charge placed at that point".

Formula:

In order to find the value of electric intensity at a point in the field, of charge **+ q**, we place a test charge $\mathbf{q_0}$ at that point. If **F** is the force acting on the test charge $\mathbf{q_0}$, the electric field intensity is given by

$$\mathbf{E} = \frac{\mathbf{F}}{\mathbf{q_o}}$$

Electrical Force:

If the electric field due to a given arrangement of charges is known at some point, the force on any particle with charge q placed at that point can be calculated by using the formula:

$$\mathbf{F = q\,E}$$

Type of Quantity:

Electric field intensity is a vector quantity. It has the same direction as that of force acting on the positive test charge. If the test charge is free to move, it will always move in the direction of electric intensity.

Unit:

SI unit of electric intensity is $\mathbf{N\,C^{-1}}$.

Q.2 What is meant by electric lines of force? Write their characteristics. *(K.B)*
(LHR 2014, LHR 2015)

Ans: **ELECTRIC FIELD LINES**

Introduction:

The direction of electric field intensity in an electric field can also be represented by drawing lines. These lines are known as electric lines of forces. These lines were introduced by Michael Faraday;

Definition:

The field lines are imaginary lines around a field charge with an arrow head indicating the direction of force.

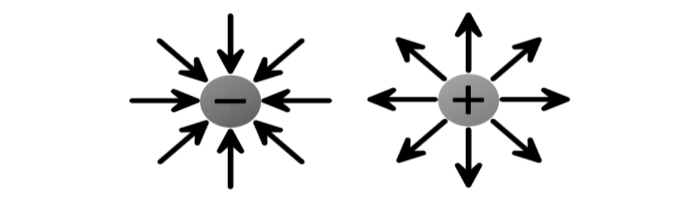


Figure: **Electric Field Lines of Isolated Positive & Negative Charge**

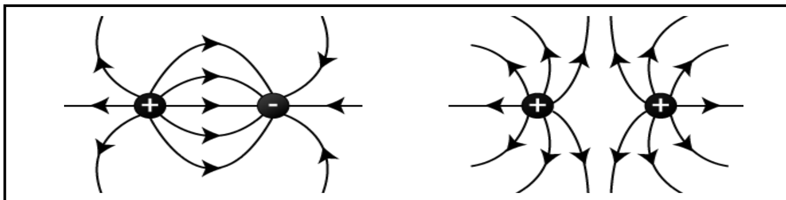


Figure: **(a) Electric Field Lines of Two Opposite & Equal Charges**
(b) Electric Field Lines of Two Same & Equal Charges

Characteristics:

- These are imaginary lines.
- They never intersect each other.
- Their direction is always from positive charge to negative charge.
- They are closer near the charge and wider away from the charge.

13.5SHORT QUESTIONS

Q.1 Define electric field intensity? *(K.B)* **(GRW 2014)**

Ans: ***Given on Page # 166***

Q.2 Who introduce the electric lines of force? *(K.B)*

Ans: ***Given on Page # 167*** **(LHR 2013)**

Q.3 Are the electric field lines physical entities? *(K.B)*

Ans: **NATURE OF ELECTRIC FIELD LINES**

Electric field lines themselves are not physical entities. They are just used for the pictorial representation of another physical quantity i.e. electric field at various positions.

Q.4 What is work of Charles Coulomb? *(K.B)*

Ans: ***Given on Page # 164***

Q.5 What is direction of electric intensity? *(K.B)*

Ans: **DIRECTION OF ELECTRIC INTENSITY**

Electric intensity being a force is a vector quantity. Its direction is the same as that of the force acting on the positive test charge.

Q.6 On which factors the value of K depends? *(U.B+K.B)*

Ans: *Given on Page # 164*

Q.7 In what direction will a positively charged particle move in an electric field? *(K.B)*
(Conceptual 13.3)

Ans: **DIRECTION OF POSITIVE CHARGE**

A positive charge released in an electric field will move along the direction electric field i.e. from higher potential to the lower potential.

Q.8 A strong electric field exists in the vicinity of the "Faraday cage". Yet the person inside the cage is not affected. Can you tell why? *(K.B+U.B)* (Point to ponder Pg. # 77)

Ans: **FARADAY'S CAGE**

A Faraday's cage is an enclosure made of a conducting material to block internal electric fields. In the presence of internal electric field, the electric charges on the surface of cage are redistributed in such a way so that electric field becomes zero inside the interior of Faraday's cage.

Q.9 Show variation of magnitude of Coulomb force between two opposite charges of different magnitude? *(U.B+A.B)* (Physics Insight Pg. # 77)

Ans: **VARIATION OF COULOMB FORCE**

Variation of magnitude of Coulomb's force between two opposite charges of different magnitudes.

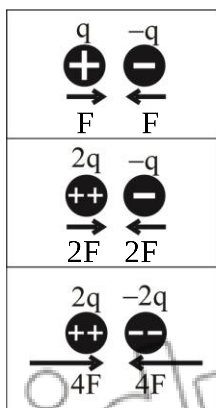


Figure: **Variation of Magnitude of Coulomb Force Between Two Opposite Charges**

Q.10 If two same charges are separated by 1 m distance having 9×10^9 N. Then relate this force with gravitational force? *(U.B+A.B)*

Between electromagnetic force and gravitational force which one is more responsible for the stability of universe. *(Conceptual Base)* (Physics Insight Pg. # 77)

Ans: **RELATION OF FORCE**

The electrostatic force acting on two charges each of 1 C separated by 1 m is about 9×10^9 N. This force is equal to the gravitational force that the earth exerts on a billion kilogram object at sea level. This means that electromagnetic force is billion time stronger than gravitational force. So electromagnetic force is more responsible for the stability of this universe.

13.5 MULTIPLE CHOICE QUESTIONS

1. **A region around the charge in which it exerts electrostatic force on another charge is called: *(K.B)***
(A) Gravitational field (B) Magnetic field
(C) Electric field (D) All of these
2. **SI unit of electric intensity is *(U.B)*** **(LHR 2014)**
(A) Nm^{-1} (B) NC^{-1}
(C) Nm^{-2} (D) Nm
3. **The spacing between the field lines shows the *(K.B)***
(A) Strength of electric field (B) Direction of electric field
(C) Both a and b (D) None of these
4. **The space around the charge within which other charges are influenced by it is called *(K.B)***
(A) Electric intensity (B) Electric field
(C) Electric flux (D) Electric potential
5. **Force experienced by a unit positive charge placed at a point in the electric field is known as: *(K.B)*** **(LHR 2017)**
(A) Electric field intensity (B) Magnetic field intensity
(C) Electric potential (D) Capacity
6. **The force per unit charge is known as *(K.B+U.B)***
(A) Electric flux (B) Electric intensity
(C) Electric potential (D) Electric volt
7. **SI unit of electric field intensity is *(A.B+K.B)*** **(GRW 2013)**
(A) Coulomb (B) Volt
(C) Newton/coulomb (D) Ampere
8. **Electric field intensity is a vector quantity and its direction is *(K.B)***
(A) Perpendicular to the direction of field (B) Opposite to the direction of force
(C) Along the direction of force (D) At a certain angle
9. **The electric intensity at infinite distance from the point charge is: *(U.B)***
(A) Zero (B) Infinite
(C) 1 Volt – m^{-1} (D) Positive
10. **Electric field is strong when line are: *(K.B)***
(A) Separated (B) Closer
(C) Smaller (D) Larger
11. **What is the electric field intensity 30 cm away from a light bulb? *(U.B+A.B)***
(A) 4 NC^{-1} (B) 5 NC^{-1}
(C) 0 NC^{-1} (D) None of these
12. **An electron in a hydrogen atom experiences an electric intensity in the order of: *(U.B+A.B)***
(A) 10^{9} NC^{-11} (B) 10^{11} NC^{-1}
(C) 10^{10} NC^{-1} (D) None of these

13. To detect the nearby objects, some animals produces *(A.B)*

(A) Electric Field (B) Magnetic Field
(C) Gravitational Field (D) None of these

14. Electric field 30 cm away from a light bulb is: *(A.B)* **(For your information Pg. # 77)**

(A) 5 NC^{-1} (B) 50 NC^{-1}
(C) 500 NC (D) None of these

15. Electric field experienced by an electron of hydrogen atom from the nucleus is of the order of: *(U.B)* **(For your information Pg. # 77)**

(A) 10^{11} NC^{-1} (B) 10^{10} NC^{-1}
(C) 10^{9} NC^{-1} (D) None of these

13.6 ELECTROSTATIC POTENTIAL

LONG QUESTION

Q.1 What is meant by electric potential? Explain. *(K.B+U.B+A.B)* **(GRW 2013)**

Ans:

ELECTRIC POTENTIAL

Definition:

"Electric potential at a point in an electric field is equal to the amount of work done in bringing a unit positive charge form infinity to that point."

Mathematically:

If W is the **work done** in moving a **unit positive charge** *q* from **infinity** to a certain point in the field, the **electric potential** V at this point would be given by

$$V = \frac{W}{q}$$

It implies that electric potential is measured relative to some reference point and like potential energy we can measure only the change in potential between two points.

Quantity:

Electric potential is a scalar quantity.

Unit:

It SI unit is volt which is equal to $\mathbf{JC^{-1}}$

Volt:

If one joule of work is done against the electric field in bringing one coulomb positive charge from infinity to a point in the electric field then the potential at that point will be one volt. Or if the potential energy of one coulomb of charge at a point in the electric field is one joule, the potential of the point will be one volt.

POTENTIAL DIFFERENCE

Definition: **(Review 13.12)**

"The **energy supplied** by a **unit charge** as it moves from one point to the other in the direction of the field is called potential difference between two points".

Explanation: **(Review 13.13)**

A body in gravitational field always tends to move from a point of higher potential energy to a point of lower potential energy. Similarly, when a charge is released in a electric field, it moves from a point of higher potential say A to a point at lower potential say B.

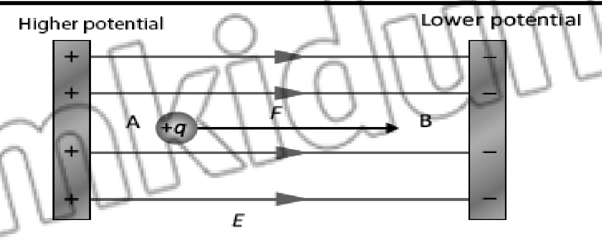


Figure: **Potential Difference between Two Points**

If the potential of point **A** is $\mathbf{V_a}$ and that of point **B** is $\mathbf{V_b}$ the potential energy of the charge at these points will be $\mathbf{qV_a}$ and $\mathbf{qV_b}$ respectively. The change in potential energy of the charge when it moves from point **A** to **B** will be equal to $\mathbf{qV_a - qV_b}$. This energy is utilized in doing some useful work.

Thus Energy supplied by the charge $= \mathbf{q(V_a - V_b)}$

If q is equal to one coulomb, then the potential difference between two points becomes equal to the energy supplied by the charge. Thus, we define potential difference between two points as:

- If a positive charge is transferred form a point of lower potential to a point of higher potential i.e. against the field direction, energy would have to be supplied to it.
- When we release a negative charge in an electric field, its behaviour will be opposite to that of positive charge. A more useful unit for the electrical energy is electron volt **(eV)**.

13.6 SHORT QUESTIONS

Q.1 What is meant by electric potential? ***(K.B)***

Ans: ***Given on Page # 170***

Q.2 Define potential difference between two points. ***(K.B+U.B)***

Ans: ***Given on Page # 170***

Q.3 What is electron volt? Also find its energy in joules. ***(U.B+A.B+K.B)***

Ans: **ELECTRON VOLT**

Definition:

"It is equal to the amount of energy supplied by an electron as it moves between two points having a potential difference of one volt**"**.

Mathematically:

Charge on an electron = q = 1 .6 x 1 0^{-19} C.

Potential difference $\Delta v = V_A - V_B = 1$ V

1 eV = 1.6 x 1 0^{-19} C x 1 V

1 eV = 1.6 x 10^{-19} J

Result:

Hence, 1 eV = 1.6 x 10^{-19} J

Q.4 Is the presence of charge necessary for the existence of electrostatic potential? ***(K.B)***

Ans: **EXISTENCE OF ELECTRIC POTENTIAL**

Yes, the presence of charge is necessary for the existence of electrostatic potential. Electric potential is the work done in bringing a unit +ve charge from infinity to a point inside the electric field. Hence to produce electric field charge is necessary.

Q.5 What is the difference between electric potential and electric potential energy? *(K.B)*

Ans: **DIFFERENTIATION**

The difference between electric potential and electric potential energy is as follows:

Electric Potential	Electric Potential Energy
• Electric potential is a characteristic of the field of source charge and is independent of a test charge that may be placed in the field.	• Potential energy is a characteristic of both the field and test charge. It is produced due to the interaction of the field and the test charge placed in the field.

Q.11 What is positive test charge? And why it is used to measure electric field and electric potential? *(C.B+A.B)*

Ans: A positive test charge is a positive charge having unit magnitude and it is used to measure electric field and electric potential because its electric field is negligible.

13.6 MULTIPLE CHOICE QUESTIONS

1. The magnitude of the charge on the electron is: *(K.B)*

(A) 1.2×10^{-19}C (B) 1.6×10^{-19}C
(C) 2.6×10^{-19}C (D) 1.81×10^{-19}C

2. Work done in bringing a unit positive charge from infinity to that point in an electric field is called: *(K.B)*

(A) Potential difference (B) Resistance
(C) Capacitance (D) Electric potential

3. Which point in an electric field is equal to amount of work done in bringing unit positive charge from infinity to that point? *(K.B)*

(A) Electric intensity (B) Potential difference
(C) Electric potential (D) Volt

4. Which statement is true about electrical potential?*(K.B)*

(A) Its SI unit is volt (B) It is scalar quantity
(C) At any point $v = \frac{w}{q}$ (D) All of these

5. The potential difference between two points is one volt. The amount of work done in moving a charge of one coulomb from one point to another is: *(U.B)*

(A) One erg (B) One Joule
(C) One electron volt (D) One coulomb

6. Electron volt is the unit of: *(K.B)*

(A) Potential difference (B) Electric energy
(C) Electric current (D) Capacitance

7. The electron energy is one electron – volt when it is accelerated through a potential difference of: *(K.B)*

(A) One volt (B) One joule
(C) One Coulomb (D) One erg

8. Electric potential is a: *(K.B)*

(A) Vector quantity (B) Scalar quantity
(C) Neither scalar nor vector (D) Sometimes scalar and sometimes vector

9. One electron volt is equal to: ***(U.B)***

(A) 1.6×10^{-19}J (B) 1.6×10^{19}J

(C) 6.25×10^{-18}J (D) 6.25×10^{18}J

10. The work done in moving a unit positive charge from one point to another against the electric field is a measure of: ***(K.B)***

(A) Intensity of electric field (B) Resistance between two points

(C) Capacitance (D) Potential difference between two points

11. Voltage across a device has the same meaning of: ***(K.B)***

(A) e.m.f (B) Potential difference

(C) Potential energy (D) None of these

13.7 CAPACITORS AND CAPACITANCE, COMBINATION OF CAPACITOR

LONG QUESTIONS

Q.1 Define and explain capacitor. ***(K.B+U.B+A.B)*** **(GRW 2014, LHR 2014)**

Ans: **CAPACITOR**

Definition:

"Capacitor is a device which is used to store the electric charge**"**.

Construction:

It consists of two thin metal plates, parallel to each other separated by a very small distance. The medium between the two plates is air or a sheet of some insulator. This medium is known as dielectric.

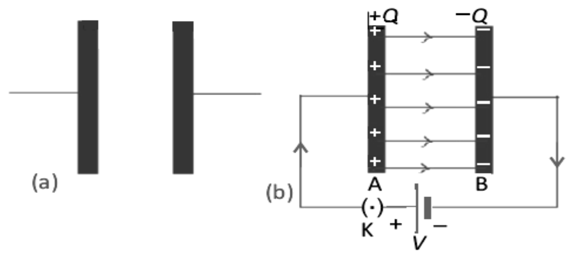


Figure: (a) Parallel Plate Capacitor, (b) Plates of Capacitor Connected with Battery

Charging of a Capacitor: **(Review 13.14)**

If a capacitor is connected to a battery of V volts, then the battery transfers a charge +Q from plate B to plate A, so that -Q charge appears on plate B and +Q charge appears on plate A.

The charges on each plate attract each other and thus remain bound within the plates. In this way, charge is stored in a capacitor for a long time.

Mathematical Expression:

The **charge** Q stored on plates is **directly proportional** to the **potential difference** V across the plates i.e.

$Q \propto V$

$Q = CV$

Where C is the constant of proportionality, called the capacitance of the capacitor.

Capacitance:

The ability of the capacitor to store charge is called its capacitance.

Formula:

$$C = \frac{Q}{V}$$

Unit:

S.I unit of capacitance is Farad (F)

Farad:

"If **one coulomb** of charge given to the plates of a capacitor produces a potential difference of **one volt** between the plates of the capacitor then its capacitance would be **one farad**".

Smaller Unit:

Farad is a large unit, usually, we use a smaller unit such as micro farad **(μF)**, Nano farad **(nF)** and Pico farad **(pF)** etc.

Dependence:

It depends upon

- Type of insulator between the plates of a capacitor.
- Distance between the plates of a capacitor.
- Area of the plates of a capacitor.

Q.2 How the capacitors are connected in parallel? Describe the characteristics features of this combination. ***(U.B+A.B+K.B)*** **(LHR 2014, 2017)**

OR Derive the formula for the equivalent capacitance for a parallel combination of a number of capacitors.

Ans: **PARALLEL COMBINATION OF CAPACITORS**

Definition:

In this combination, the left plate of each capacitor is connected to the positive terminal of the battery by a conducting wire. In the same way, the right plate of each capacitor is connected to the negative terminal of the battery.

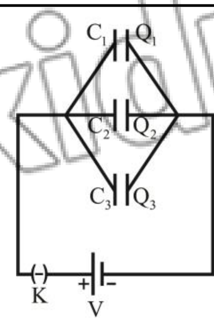


Figure: **Parallel Combination of Capacitor**

Characteristics of Parallel Combination:

This type of combination has the following characteristics:

1. Each capacitor connected to a battery of voltage V has the same potential difference V across it. i.e.
$V_1 = V_2 = V_3 = V$
2. The charge developed across the plates of each capacitor will be different due to different value of capacitances.
3. The total charge Q supplied by the battery is divided among the various capacitors. Hence,

$$Q = Q_1 + Q_2 + Q_3$$
$$Q = C_1V + C_2V + C_3V$$
$$Q = V(C_1 + C_2 + C_3)$$
$$\frac{Q}{V} = C_1 + C_2 + C_3$$

4. Thus, we can replace the parallel combination of capacitors with one equivalent capacitor having capacitance C_{eq}, such that

$$C_{eq} = C_1 + C_2 + C_3$$

In the case of 'n' capacitors connected in parallel, the equivalent capacitance is given by
$C_{eq} = C_1 + C_2 + C_3 + ... + C_n$

Conclusion:

The equivalent capacitance of a parallel combination of capacitors is greater than any of the individual capacitances.

Q.3 How the capacitors are connected in series? Describe the characteristics features of this combination. *(U.B+A.B+K.B)* (Review 13.16) (LHR 2013, LHR 2015, 2017)

OR Derive the formula for the equivalent capacitance for a series combination of a number of capacitors.

Ans:

SERIES COMBINATION OF CAPACITORS

Definition:

In this combination, the capacitors are connected side by side i.e., the right plate of one capacitor is connected to the left plate of the next capacitor.

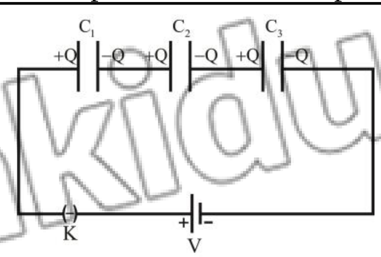


Figure: Series Combination

Characteristics:

This type of combination has the following characteristics:

1. Each capacitor has the same charge across it. If the battery supplies +Q charge to the left plate of the capacitor C1 due to induction –Q charge is induced on its right plate and +Q charge on the left plate of the capacitor C_2 i.e.,
$Q_1 = Q_2 = Q_3 = Q$

2. The potential difference across each capacitor is different due to different values of capacitances.
3. The voltage of the battery has been divided among the various capacitors. Hence

$$V = V_1 + V_2 + V_3$$

$$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$V = Q(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3})$$

$$\frac{V}{Q} = (\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3})$$

4. Thus, we can replace series combination of capacitors with one equivalent capacitor having capacitance C_{eq}.i.e.

$$\frac{1}{C_{eq}} = (\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3})$$

In the case of 'n' capacitors connected in series, we have

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} .... + \frac{1}{C_n}$$

Conclusion:

The equivalent capacitance of a series combination of capacitors is less than any of the individual capacitances.

13.7 SHORT QUESTIONS

Q.1 What is difference between battery and capacitor? *(Conceptual Base)*

Ans: The main difference between Battery and Capacitor is Battery store electrical energy in the form of chemical energy whereas the Capacitor store electrical energy in the form of electrical charge. The capacitor supply all its energy at once but battery supply its energy for a long time. Battery can store charges for a long time but capacitor cannot store charges for a long time.

Q.2 What is meant by capacitance? *(K.B)*

Ans: ***Given on Page # 174***

Q.3 Capacitor store charges or electrical energy? *(Conceptual Base)*

Ans: By definition, a capacitor is a device that stores energy in the form of an electric field. When a capacitor is connected across a voltage source electrons will flow from the negative terminal of the battery to the plate of the capacitor that is connected to the said terminal hence the plate will be negatively charged.

Also, the electrons will be attracted from the other plate of the capacitor to the positive terminal of the battery or the negatively charged plate will attract the positive charge on the other plate and the plate will become positively charged. This process will continue until the charge on the negative plate begins to repel the further accumulation of electrons on the plate. Now the capacitor is fully charged. In simple word we can say that capacitor just only recombine the charges but do not store them its store energy. **(LHR 2013)**

Q.4 How does capacitor store charge? *(K.B+U.B)* **(For your Information Pg. # 80)**

Ans: **CHARGING OF CAPACITOR**

If +Q amount of charge is transferred to its one plate, due to electrostatic induction it would induce -Q charge on the inner surface of other plate. There exists a force of attraction between the charges +Q stored on the first plate and the charge -Q induced on the inner surface of other plate.

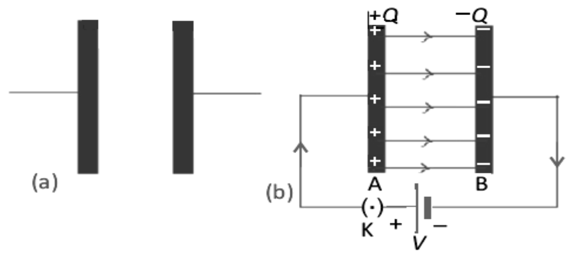


Figure: **(a) Parallel Plate Capacitor, (b) Plates of Capacitor Connected with Battery**

Due to this force of attraction, the charges are bound with the plate and remain stored for long periods.

Q.5 Why charge cannot be stored on capacitor for a long time? *(C.B)*

Ans: **CHARGE ON A CAPACITOR**

Charge cannot be stored on a conductor for a long period of time because the stored charges mutually repel each other due to which they spread on the whole surface of the conductor and also tend to leak out from there.

Q.6 What is parallel combination of capacitor? *(K.B)*

Ans: ***Given on Page # 174***

Q.7 What is series combination of capacitor? *(K.B)*

Ans: ***Given on Page # 175***

Q.8 What is the relation between equivalent capacitance of parallel combination and individual capacitance of each capacitor in this combination? *(U.B+A.B+K.B)*

OR Is the equivalent capacitance of parallel capacitors larger or smaller than the capacitance of any individual capacitor in the combination? *(U.B+A.B+K.B)*
(Quick quiz Pg. # 80)

Ans: **RELATION**

The equivalent capacitance of a parallel combination of capacitors is greater than any of the individual capacitances as related under;

$C_{eq} = C_1 + C_2 + C_3 + ... + C_n$

Q.9 What is the relation between equivalent capacitance of series combination and individual capacitance of each capacitor in this combination? *(U.B+A.B+K.B)*

OR Is the equivalent capacitance of series capacitors larger or smaller than the capacitance of any individual capacitor in the combination? *(U.B+K.B+A.B)*
(Quick quiz Pg. # 81)

Ans: **RELATION**

The equivalent capacitance of a series combination of capacitors is less than any of the individual capacitances as related under;

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} .... + \frac{1}{C_n}$$

Q.10 Defined farad. ***(K.B+UB.)***

Ans: *Given on Page # 175*

Q.11 What is the working principle of capacitor? ***(K.B)***

Ans: Capacitor is a device that is used to store charges. It works on the principle of electrostatic induction which is defined as

Electrostatic Induction:

In the presence of a charged body, an insulated conductor develops positive charge at one end and negative charge at the other end.

Q.12 Does each capacitor carry equal charge in series combination? Explain. **(Conceptual 13.4)**

Ans: **CHARGE ON CAPACITORS IN SERIES**

As in series combination each capacitor is connected side by side, so each capacitor carries equal magnitude of charge due to electrostatic induction.

Q.13 Each capacitor in parallel combination has equal potential difference between its two plates. Justify the statement. ***(K.B+U.B)*** **(Conceptual 13.5)**

Ans: **POTENTIAL DIFFERENCE IN PARALLEL COMBINATION**

In a parallel combination of capacitors, two plates of each capacitor are connected to the positive and negative terminals of a battery between the same two points. Hence potential difference between two plates of each capacitor is equal i.e equal to the potential difference of the battery.

Q.14 Capacitor blocks D.C. current but allows A.C. current to pass through a circuit. How does this happen? ***(U.B+C.B)*** **(Point to ponder Pg. # 84)**

Ans: **CAPACITOR BLOCKS D.C**

D.C current flows only in one direction. When capacitor connected' to any D.C source (e.g battery) is fully charged there is no further flow of current in the circuit. In case of A.C the polarity of A.C. source changes again and again due to which charge polarity on the plates of capacitor also changes. Due to this reason. A.C. is not stopped or blocked through the circuit.

Q.15 How capacitor store energy? ***(K.B)*** **(Point to ponder Pg. # 84)**

Ans: **CAPACITOR STORE ENERGY**

Capacitor stores energy in an electric field between two plates in the form of electrostatic potential energy.

Q.16 What are the factors on which the capacitance of a capacitor depends? ***(K.B+U.B)***

Ans: **FACTORS AFFECTING CAPACITANCE**

Three factors affects the ability of a capacitor to store the charge.

- Area of the plates
- Distance between the plates
- Type of insulator used between the plates

13.7 MULTIPLE CHOICE QUESTIONS

1. In order to store the charge a device is used which is called: ***(K.B)***

(A) Potential (B) Capacitor
(C) Momentum (D) Voltage

2. SI unit of capacitance: ***(K.B)*** **(LHR 2013, 2017)**

(A) Farad (F) (B) Coulomb
(C) Newton (D) Voltage

3. Parallel plate capacitor consists of two metal plates separated by: *(K.B)*

(A) Metal (B) Insulator
(C) Conductor (D) All of these

4. Which is incorrect for parallel capacitor? *(U.B)*

(A) $v_1 = v_2 = v_3 = v$ (B) $Q = Q_1 + Q_2 + Q_3$
(C) $C_e = C_1 + C_2 + C_3$ (D) $Q_1 = Q_2 = Q_3 = Q$

5. The capacitance C of a capacitor is given by the relation *(U.B)* **(LHR 2017)**

(A) C = QV/2 (B) C = QV
(C) C = Q/V (D) C = V/Q

6. A capacitor is a perfect insulator for *(K.B)*

(A) Direct current (B) Alternating current
(C) Both for the direct and alternating current (D) Electric charge

7. Which one of the following is correct? *(K.B)*

(A) 1 μF = 10^{-6}F (B) 1ρF = 10^{-13}F
(C) 1ρF = 10^{-6}μ F (D) All of the above

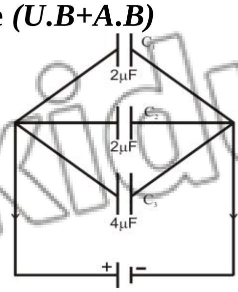
8. When capacitors are connected in parallel, their equivalent capacitance is equal to(K.B)

(A) The product of their individual capacitances
(B) The sum of their individual capacitances
(C) The product of their individual reciprocal capacitances
(D) The sum of the reciprocals of the individual capacitances

9. When capacitors are connected in series, their equivalent capacitance is equal to *(K.B)*

(A) The product of their individual capacitances
(B) The sum of their individual capacitance
(C) The sum of the reciprocals of the individual capacitances
(D) The product of their individual reciprocal capacitances

10. Three capacitors C_1, C_2 and C_3 are connected in parallel as in the Fig. Their equivalent capacitance will be *(U.B+A.B)*



(A) 8μF (B) 0.8μF
(C) 1μF (D) 16μF

11. Tick the correct statement: *(K.B)*

(A) Capacitance decreases in parallel combination
(B) Capacitance decreases in series combination
(C) Capacitance is the same in both combinations
(D) All of the above

12. If 4μF and 2μF capacitors are connected in series, the equivalent capacitance is given by: *(U.B+A.B)*

(A) 6μF (B) 2μF
(C) 1.3μF (D) 8μF

13. Two 50μF capacitors are connected in parallel. The equivalent capacitance of the combination is: *(U.B+A.B)*

(A) 1μF (B) 100μF
(C) 50μF (D) 25μF

14. The equivalent capacitance is greater than individual capacitance in *(K.B)*

(A)Series combination (B) Parallel combination
(C) Series and parallel combination (D) All of them

15. Farad is defined as *(K.B)*

(A) Coulomb/Volt (B) Ampere/Volt
(C) Coulomb/Joule (D) Joule/coulomb

EXAMPLE 13.2

The capacitance of parallel plate capacitor is 100 μC. If the potential difference between its plate is 50 volts, find the quantity of charge on each plate. *(A.B+U.B)*

Solution:

Given Data:

Capacitance of a capacitor = C = 100 μC

Voltage =V = 50 V

To Find:

Capacitance = C =?

Formula:

Q = CV

Calculations:

Putting the values from given data in the formula.

$$Q = 100 \times 10^{-6} \times 50$$

$Q = 5 \times 10^{-3}$ C = 5 mC

Result:

Hence, charge of each plate will be 5 mC because each plate has equal amount of charge.

EXAMPLE 13.3

Three capacitors with capacitances of 3.0 μF, 4.0 μF and 5.0 μF are arranged in parallel combination with a battery of 6 V, where 1 μF = 10^{-6} F. Find *(A.B+U.B)*

(a) The total capacitance

(b) The voltage across each capacitor

(c) The quantity of charge on each plate of the capacitor

Solution:

Given Data:

Capacitance of first capacitor = C_1 = 3 μF

Capacitance of second capacitor = C_2 = 4 μF

Capacitance of third capacitor = C_3 = 5 μF

Voltage = V = 6 Volts

To Find:

(i) Equivalent capacitance = C_{eq} =?

(ii) Charge on one capacitor = Q_1 =?

(iii) Charge on second capacitor = Q_2 =?

(iv) Charge on third capacitor = Q_3 =?

(v) Potential difference across each capacitor = V =?

Formula:

$C_{eq} = C_1 + C_2 + C_3$ ———— (1)

$Q_1 = C_1V$ ———— (2)

$Q_2 = C_2V$ ———— (3)

$Q_3 = C_3V$ ———— (4)

Calculations:

(i) Putting the values from given data in the formula (1)

$C_{eq} = 3\mu F + 4\mu F + 5\mu F$

$C_{eq} = 12\mu F$

(ii) Putting the values from given data in the formula (2)

$Q_1 = 3\mu F \times 6\ V$

$Q_1 = 18\ \mu C$

(iii) Putting the values from given data in the formula (3)

$Q_2 = 4\ \mu\ F \times 6\ V$

$Q_2 = 24\ \mu C$

(iv) Putting the values from given data in the formula (4)

$Q_3 = 5\ \mu\ F \times 6\ V$

$Q_3 = 30\ \mu C$

(v) Since the capacitors are connected in parallel, therefore, potential difference across each capacitor will be 6V.

Conclusion:

Hence,

Equivalent capacitance of parallel combination is 12μF.
Charge on each first capacitor is 18 μC.
Charge on each second capacitor is 24 μC.
Charge on each third capacitor is 30 μC.
Potential difference across each capacitor is 6V.

EXAMPLE 13.4

Three capacitors with capacitances of 3.0 μF, 4 μF and 5 μF are arranged in series combination to a battery of 6 V, where 1 μF = 10^{-6} F. Find ***(A.B+U.B)***

(a) The total capacitance of the series combination

(b) The quantity of charge across each capacitor

(c) The voltage across each capacitor

Solution:

Given Data:

Capacitance of first capacitor = C_1 = 3 μF

Capacitance of second capacitor = C_2 = 4 μF

Capacitance of third capacitor = C_3 = 5 μF

Voltage = V = 6 Volts

To Find:

(i) Equivalent capacitance = C_{eq} =?

(ii) Charge on each capacitor = Q =?

(iii) Potential difference across one capacitor = V_1 =?

Potential difference across second capacitor = V_2 =?

Potential difference across Third capacitor = V_3 =?

Formula:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{———— (1)}$$

$$Q = CV \quad \text{———— (2)}$$

$$V_1 = \frac{Q}{C_1} \quad \text{———— (3)}$$

$$V_2 = \frac{Q}{C_2} \quad \text{———— (4)}$$

$$V_3 = \frac{Q}{C_3} \quad \text{———— (5)}$$

Calculations:

(i) Putting the values from given data in the formula (1).

$$\frac{1}{C_{eq}} = \frac{1}{3\mu F} + \frac{1}{4\mu F} + \frac{1}{5\mu F}$$

$$\frac{1}{C_{eq}} = \frac{20+15+12}{60\mu F}$$

$$\frac{1}{C_{eq}} = \frac{47}{60\mu F}$$

$$C_{eq} = \frac{60\mu F}{47}$$

$C_{eq} = 1.3\ \mu F$

(ii) Putting the values from given data in the formula (2).

$Q = 1.3 \times 10^{-6}\ F \times 6V$

$Q = 7.8 \times 10^{-6}\ FV$

$Q = 7.8\ \mu C$

(iii) Putting the values from given data in the formula (3).

$$V_1 = \frac{7.8\mu C}{6\mu F} = 2.6V$$

(iv) Putting the values from given data in the formula (4).

$$V_2 = \frac{7.8\mu C}{4\mu F} = 1.9V$$

(v) Putting the values from given data in the formula (5).

$$V_2 = \frac{7.8\mu C}{5\mu F} = 1.56V$$

Conclusion:

Hence,

- **Equivalent capacitance of parallel combination is 12μF.**
- **Charge on each capacitor is 7.8 μC.**
- **Potential difference across one capacitor is 2.6 V.**
- **Potential difference across second capacitor is 1.9 V.**
- **Potential difference across third capacitor is 1.56 V.**

13.8 DIFFERENT TYPES OF CAPACITORS

LONG QUESTIONS

Q.1 Discuss different types of capacitors. ***(K.B+A.B)***

(Review Question 13.15)(LHR 2015)

Ans:

TYPES OF CAPACITORS

Capacitors have different types depending upon their construction and the nature of dielectric used in them. Capacitors are either variable or fixed. In variable capacitors,

- Fixed capacitor
- Variable capacitor

FIXED CAPACITOR

Definition:

"If the capacitor is such that its plates are immovable, it is known as a fixed capacitor. Its value does not change**"**.

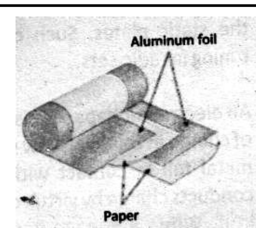


Figure: Paper Capacitor

Types of Fixed Capacitor:

- Paper capacitor
- Mica capacitor

Paper Capacitors:

Paper capacitor is an example of fixed capacitors. The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminium foils. The paper or plastic sheet firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

Mica Capacitor: **16)**

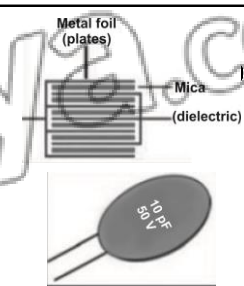


Figure: Mica Capacitor

Capacitor another example of fixed capacitors. In these capacitors, mica is used as dielectric between the two metal plates. Since mica is very fragile. For convenience and safety purposes it is enclosed in a plastic case or in a case of some insulator. Wires attached to plates project out of the case for making connections.

If the capacitance is to be increased, large number of plates is piled up, one over the other with layers of dielectric in between and alternative plates are connected with each other.

VARIABLE CAPACITOR

Definition: **(GRW 2013, LHR 2013, 2017)**

"The capacitor whose capacitance can be increased or decreased is called variable capacitor**"**.

Construction:

In variable type of capacitors, some arrangement is made to change the area of the plates facing each other. It is generally a combination of many capacitors with air as dielectric. It consists of two sets of plates. One set remains fixed while the other set can rotate so the distance between the plates does not change and they do not touch each other. The common area of the plates of the two sets which faces each other, determines the value of capacitance. Thus, the capacitance of the capacitor can be increased or decreased by turning the rotatable plates in or out of the space between the static plates. Such capacitors are usually utilized for tuning in radio sets.

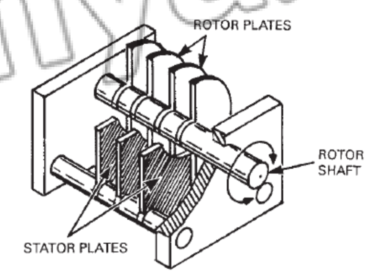


Figure: Variable Capacitor

An Electrolytic Capacitor:

An electrolytic capacitor is often used to store large amounts of charge at relatively low voltages. It consists of a metal foil in contact with an electrolyte –a solution that conducts charge by virtue of the motion of the ions contained in it.

When a voltage is applied between the foil and the electrolyte, a thin layer of metal oxide (an insulator) is formed on the foil, and this layer serves as the dielectric. Enormous capacitances can be attained because the dielectric layer is very thin.

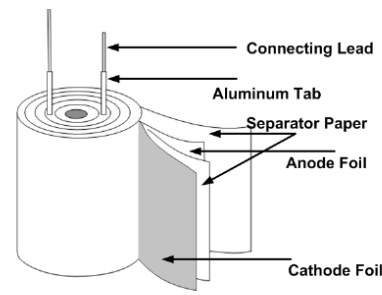


Figure: Electrolytic Capacitor

Q.2 Write down few uses of capacitors. ***(A.B)*** **(Review Question 13.17)(GRW 2013, LHR 2015)**

Ans:

USES OF CAPACITORS

Capacitors have wide range of applications in different electrical and electronic circuits.

For Tuning Some Appliance:

They are used for turning transmitters, receivers and transistor radios.

For Home Appliance:

They are used for table fans, celling fans, exhaust fans, fan motors in air conditioners; coolers, motors washing machines, air conditioners and many other appliances for their smooth working.

In Electronic Circuits:

Capacitors are used in electronic circuits of computers etc.

Low and High Frequency:

Capacitors can be used to differentiate between high frequency and low frequency signal which make them useful in electronic circuits.

Filter Circuit:

Capacitors are used in the resonant circuits that tune radios to particular frequencies. Such circuits are called filter circuit.

13.8 SHORT QUESTIONS

Q.1 What do you know about paper capacitor? *(K.B)*

Ans: **PAPER CAPACITOR**

Paper capacitor is an example of fixed capacitors. The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminum foils. The papers or plastic sheet is firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

Q.2 How electrolytic capacitor is important? *(K.B)*

Ans: **IMPORTANCE OF ELECTROLYTIC CAPACITOR**

An electrolytic capacitors in important because it is often used to store large amounts of charge at relatively law voltages.

Q.3 Write any two uses of capacitor. *(A.B)*

Ans: **USES OF CAPACITOR**

The uses of capacitor are as follows:

For Tuning Some Appliance:

They are used for turning transmitters, receivers and transistor radios.

Filter Circuit:

Capacitors are used in the resonant circuits that tune radios to particular frequencies. Such circuits are called filter circuit.

13.8 MULTIPLE CHOICE QUESTIONS

1. **In variable capacitors: *(K.B)***
   (A) Both the sets of plates are fixed
   (B) Both the sets of plates are moveable
   (C) One set of plates is fixed and the other is moveable
   (D) Both the sets of plates are neither fixed not moveable
2. **Variable capacitors are used in *(A.B)***
   (A) Radio only (B) Television only
   (C) Radio and television (D) None of the above
3. **A radio tuning capacitor is a *(K.B)***
   (A) Variable parallel plate capacitor (B) Variable cylindrical capacitor
   (C) Spherical capacitor (D) Tubular capacitor
4. **Which of the following is commercial type capacitor *(K.B)***
   (A) Tubular capacitor (B) Electrolytic capacitor
   (C) Miniature capacitors (D) All of the above
5. **Capacitor have different types depending upon: *(K.B)***
   (A) Their construction (B) Nature of dielectric
   (C) Both A and B (D) None of above
6. **In variable capacitors, the value of capacitance can be: *(K.B)***
   (A) Decrease (B) Increased
   (C) Both a and B (D) Fixed
7. **In fixed type of capacitors, the value of capacitance: *(K.B)***
   (A) Increase (B) Decrease
   (C) Cannot be changed (D) All of these
8. **It is a fixed capacitor: *(K.B)***
   (A) Paper capacitor (B) Mica capacitor
   (C) Both a and b (D) Capacitors in radio sets

9. In Mica capacitors the dielectric is: *(K.B)*

(A) Aluminum foils (B) Mica
(C) Copper (D) Polythene paper

10. Capacitors are used in: *(A.B)*

(A) Tuning Transmitters (B) Receiver
(C) Transistor radio (D) All of these

11. Capacitors are used in resonant circuit that tune radios to particular frequency: *(A.B)*

(A) Paper capacitor (B) Mica capacitor
(C) Electrolytic capacitor (D) Radio capacitor

13.9 APPLICATIONS OF ELECTROSTATICS
13.10 SOME HAZARDS OF STATIC ELECTRICITY LIGHTENING

LONG QUESTIONS

Q.1 Discuss in detail important application of electrostatic.
OR Write a note on the following *(K.B+U.B+A.B)*
(a) Electrostatic air cleaner **(LHR 2016, 2017)**
(b) Spray Painting
OR Discuss one application of static electricity. **(Review Question 13.18)**

Ans: **APPLICATION OF ELECTROSTATICS**

Static electricity has an important place in our everyday lives which include photocopying, car painting, and extracting dust from dirty carpets and from chimneys of industrial machinery.

Electrostatic Air Cleaner:

An electrostatic air cleaner is used in homes to relieve that discomfort of allergy sufferers.

Working of Electric Static Air Cleaner:

Air mixed with dust and pollen enters the device across a positively charged mesh screen.

The airborne particles become positively charged when they make contact with the mesh. Then they pass through a second, negatively charged mesh screen.

The electrostatic force of attraction between the positively charged particles in the air and the negatively charged screen cases the particles to precipitate out on the surface of the screen. Through this process we can removes a very high percentage of contaminants form the air stream.

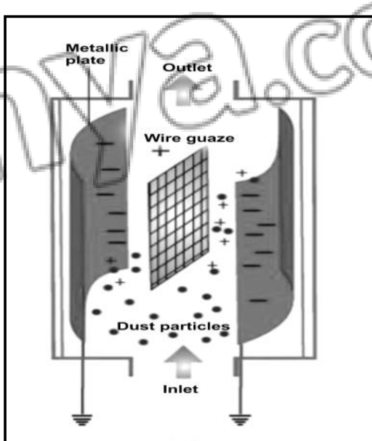


Figure: Electrostatic Air Cleaner

Spray Painting:

Automobile manufacturers use static electricity to paint new cars.

Working of Electrostatic Spray Painting:

The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer.

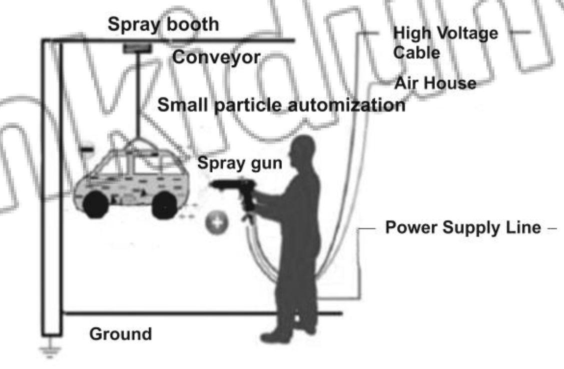


Figure: **Electrostatic Spray Painting**

Due to mutual repulsion charge particles pushed out of the nozzle form a fine mist and are evenly distributed on the surface of the object. The charged paint particles are stick to the body, just like a charged balloon sticks to a wall. Once the paint dries. It sticks much better to the car and is smoother because is the uniformly distributed. This is a very effective, efficient and economical way of painting automobiles on large scale.

Q.2 What are the hazards of static electricity? Explain them. ***(K.B)***

(Review Question 13.19)

HAZARD OF STATIC ELECTRICITY

There are so many hazards of static electricity. We are discussing only two of them.

- Lightening
- Fires or Explosions

Lightening:

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it induced opposite charge on the objects present on the ground giving rise to a strong electric field between the cloud and the ground. Suddenly, the charge in cloud jumps to the ground with a violet spark and explosion.

This explains why it is very dangerous to swim in the open sea, play in an open filed or hide under a tree during a thunderstorm.

Precaution or Prevention:

To prevent lightening from damaging tall buildings, lightening conductors are used. The purpose of the lightening conductor is to provide a safe discharge path for the large amount of negative charge in the air to flow form the top of the building to the Earth. In this way the chances of lightening damage due to sudden discharge can be minimized.

Fires or Explosions:

Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction.

Production of Static Electricity:

Static electricity can be generated by the friction of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing. Static charge are dangerous. If static charges are allowed to discharge though the areas where there is petrol vapour a fire can occur.

The results are frightening and may be devastating.

Portable oil containers can build up a static electric charge during transport. Consequently, when the container is not placed on the ground for filling, its static electricity could be discharged and result in a fire when filling begins.

Precaution or Prevention

Precaution or prevention containers should be placed on the ground during filling and the nozzle should be kept in contact with the container. Containers should not to be filled while inside a vehicle.

13.9, 13.10 SHORT QUESTIONS

Q.1 How the phenomenon of lightening occurs? *(K.B)*

Ans: **LIGHTENING**

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunder clouds. The thunderclouds are charged by friction between the water molecules in the thunder clouds and the air molecules. When the charge on the thunder clouds is sufficiently high, it can produce positive and negative charges in the air. The huge amount of negative charge is discharged to the highest object on the ground and can harm them.

Q.2 How static charges are dangerous? *(U.B)*

Ans: **DANGERS OF STATIC CHARGES**

If static charges are allowed to discharge through the area where there is petrol vapours, a fire can occur. The results are frightening and may be devastating.

Q.3 Why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm? *(C.B+A.B)*

Ans: **DANGER DURING THUNDERSTORM**

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it can produce positive and negative charges in the air. The he amount of negative charge is discharged to the highest object on the ground and can harm them.

This explains why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm.

Q.4 How is Static electricity a major cause of fires and explosions at many places? *(A.B)*

Ans: **FIRES AND EXPLOSIONS**

Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction.

Q.5 How automobile manufactures use static electricity to paint new cars? *(A.B)*

Ans: **ELECTROSTATIC PAINTING**

The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer. Due to mutual repulsion charge particles coming out of the nozzle form a fine mist and are evenly distributed on the surface of the object.

Q.6 Why lightening conductors are used in tall buildings? *(A.B)*

Ans: **LIGHTENING CONDUCTORS**

The purpose of the lightening conductor is to provide a steady discharge path for the large amount of negative charge in the air to flow form the top of the building to the earth. In this way, the chances of lightening damage due to sudden discharge can be minimized.

Q.7 Write any two examples of practical application of electrostatic induction? *(A.B)*

Ans: **APPLICATION OF ELECTROSTATIC INDUCTION**

The applications of electrostatic induction are given as under:

- Separation of particles from smoke
- Electrostatic painting

Q.8 How static electricity can be generated? *(K.B)*

Ans: **PRODUCTION OF STATIC ELECTRICITY**

Static electricity can be generated by the frictions of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing static electric charge build up during transport.

Q.9 Rubber tires get charged from friction with the road. What is the polarity of the charge? *(K.B+U.B)*

Ans: **POLARITY OF THE CHARGE**

The charge produced on the rubber tyre due to friction between tyre and road is positive because electrons are lost by rubber tyre due to weaker bonding.

Q.10 Perhaps you have seen a gasoline truck trailing a metal chain beneath it. What purpose does the chain serve? *(U.B+A.B)* **(Conceptual 13.6)**

Ans: **PURPOSE OF METAL CHAIN**

This metal charging is used of the purpose of earthling. The static charge accumulated on the body of truck during transportation are discharged to the ground through this metal chain. This may avoid any chance of explosion or fire during filling or otherwise.

Q.11 If a high-voltage power line fell across your car while you were in the car, why should you not come out of the car? *(U.B)* **(Conceptual 13.7)**

Ans: **HIGH VOLTAGE POWER LINE**

Similar to Faraday's cage, inside the car you are safe from the influence of external field. The charge is evenly distributed on the surface of the car and the electric field inside the car is zero. But if we touch the ground. While coming out of the car, the charge will be discharged to the ground through our body. Hence it may be fatal.

Q.12 During flight, body of aeroplane gets charged. How it is discharged safely when landed? *(U.B+C.B+A.B)*

(For your information Pg. # 85)

Ans: **DISCHARGING OF AEROPLANE**

During flight, body of aeroplane gets charged. As the aeroplane lands, this charge is transferred to ground and the charge of sparking is eliminated while fuel is filled in it.

Q.13 How can we avoid spark or explosion while putting fuel in car or aircraft? *(C.B+A.B)*

(For your information Pg. # 85)

Ans: **SPARK OR EXPLOSION**

Static electricity can spark a fire or explosions. Care must be taken to avoid sparks when putting fuel in cars or aircraft. Spark may be produced due to friction between the fuel and the pipe. This can cause a serious explosion. The spark can be avoided if the pipe nozzle is made to conduct by connecting an earthing strap to it. The earthing strap connects the pipe to the ground.

Q.14 How much damage or destruction can lightening do? *(K.B)*

(For your information Pg. # 85)

Ans: **LIGHTENING**

The energy in lightening is enough to crack bricks and stones in unprotected buildings, and destroy electrical equipments inside. Each bolt of lightning contains about 1000 million joules of energy. This energy is enough to boil a kettle continuously for about two weeks. A flash of lightening is brighter than 10^7 light bulbs each of 100 watt.

Q.15 How would you suspend 500,000 pounds of water in the air with no visible means of support? *(U.B+A.B)* **(Point to ponder Pg. # 84)**

Ans: **SUSPENDING OF WATER IN AIR**

As we know that,

1 kg = 2.2 pounds and 1 pound = $\frac{1}{2.2}$ kg

So, 500,000 pounds of water $=\frac{500,000}{2.2}=2.27\times10^5\text{kg}$

And, Energy required to vaporize 1 kg of water = 2260000 J

(2260000 J = specific latent heat of vaporization of water)

Energy to vaporize $\left(2.27\times10^5\text{kg}\right)$ or $\left(500,000\text{ pounds}\right)=2.27\times10^5\times2260000\text{J}$

$=5.13\times10^{11}\text{J}$

Hence, $5.13\times10^{11}\text{J}$ energy must be supplied to a boiler to evaporate 500,000 pounds of water into air that can be supported by air particles in air which not a visible mean.

13.9, 13.10 MULTIPLE CHOICE QUESTIONS

1 **Application of electrostatic is: *(A.B)***
(A) Photocopying (B) Car painting
(C) Extracting Dust (D) All of these

2. **Each bolt of lightning contains about: *(U.B)***
(A) 100 million J of energy (B) 50 million J of energy
(C) 100 billion J of energy (D) 50 billion J of energy

3. **How many bulbs (each of 100 W) equal to a flash of lightening? *(U.B)***
(A) 10 (B) 50
(C) 100 (D) 50

4. **100 million joules energy is enough to boil a kettle continuously for about: *(U.B)***
(A) 2 weeks (B) 1 month
(C) 1 year (D) 1 hour

MCQ'S ANSWER KEY (TOPIC WISE)

13.1 PRODUCTION OF ELECTRIC CHARGES

1	2	3	4	5	6	7	8	9	10	11	12
A	C	D	A	B	A	B	A	D	B	B	A

13	14	15	16	17	18
B	A	C	C	A	B

13.2 ELECTROSTATIC INDUCTION

1
A

13.3 ELECTROSCOPE

1	2
D	C

13.4 COULOMB'S LAW

1	2	3	4	5	6	7	8	9	10	11	12
D	C	A	B	B	A	D	C	D	B	D	B

13
B

13.5 ELECTRIC FIELD AND ELECTRIC FIELD INTENSITY

1	2	3	4	5	6	7	8	9	10	11	12
C	B	A	B	A	B	C	C	A	B	B	B

13	14	15
A	A	A

13.6 ELECTROSTATIC POTENTIAL

1	2	3	4	5	6	7	8	9	10	11
B	D	C	D	B	B	A	B	A	D	B

13.7 CAPACITORS AND CAPACITANCE, COMBINATION OF CAPACITOR

1	2	3	4	5	6	7	8	9	10	11	12
B	A	B	D	C	A	A	B	C	A	B	C

13	14	15
B	B	A

13.8 DIFFERENT TYPES OF CAPACITORS

1	2	3	4	5	6	7	8	9	10	11
A	A	B	D	C	C	C	C	B	D	D

13.9 APPLICATIONS OF ELECTROSTATICS

13.10 SOME HAZARDS OF STATIC ELECTRICITY LIGHETING

1	2	3	4
D	A	A	A

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. A Positive electric charge: *(K.B)* **(LHR 2014)**
(a) attracts other positive charge
(b) repels other positive charge
(c) attracts a neutral charge
(d) repels a neutral charge

ii. An object gains excess negative charge after being rubbed against another object: *(K.B)*
(a) neutral
(b) negatively charged
(c) positively charged
(d) either a, b or c

iii. Two uncharged objects A and B are rubbed against each other when object B is placed near a negatively charged object C, the two objects repel each other which of the following statements is true about object A? *(U.B)*
(a) remains uncharged
(b) becomes positively charged
(c) becomes negatively charged
(d) unpredictable

iv. When you rub a plastic rod against your hair several times and put it near some bits of paper the pieces of papers are attracted towards it. What does this observation indicates? *(K.B+U.B)*
(a) the rod and the paper are oppositely charged
(b) the rod acquires a positive charge
(c) the rod and the paper have the same charges
(d) the rod acquires a negative charge

v. According to coulomb's law, what happens to the attraction of two oppositely charged objects as their distance of separation increases? *(K.B)*
(a) increase
(b) decreases
(c) remains unchanged
(d) cannot be determined

vi. The coulomb's law is valid for the charges which are: *(K.B)*
(a) moving and point charges
(b) moving and non-point charges
(c) stationary and point charges
(d) stationary and large size charges

vii. A positive and a negative charge are initially 4 cm apart. When they are moved closer together so that they are now only 1 cm apart, the force between them is: *(U.B+A.B)*
(a) 4 times smaller than before
(b) 4 times larger than before
(c) 8 times larger than before
(d) 16 times larger than before

viii. Five joules of work is needed to shift 10C is charge form one place to another. The potential difference between the places is: *(U.B+A.B)*
(a) 0.5 V
(b) 2 V
(c) 5V
(d) 10V

ix. Two charged spheres are separated by 2mm. Which of the following would produce the greatest attractive force? *(U.B+A.B)*
(a) + 1q and +4q
(b) – 1q and – 4q
(c) +2q and +2q
(d) +2q and -2q

x. Electric field lines: *(K.B)*
(a) always cross each other
(b) never cross each other
(c) cross each other in the region of strong field
(d) cross each other in the region of weak field

xi. Capacitance is defined as: *(U.B+A.B)* **(GRW 2014 (R), LHR 2014, LHR 2015)**
(a) VC
(b) Q/V
(c) QV
(d) V/Q

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix	x	xi
b	a	b	a	b	c	d	a	d	b	b

REVIEW QUESTIONS

13.1. How can you show by simple experiments that there are two types of electric charges?

Ans: (See Topic 13.1, Long Question-1)

13.2. Describe the method of charging bodies by electrostatic induction.

Ans: (See Topic 13.2, Long Question-1)

13.3. How does electrostatic induction differ from charging by friction?

DIFFERENT METHODS OF CHARGING

Ans: In case of charging by friction, both the bodies are in contact with each other. While, in case of electrostatic induction both the bodies are not in contact with each other.

13.4. What is gold leaf electroscope? Discuss its working principle with a labeled diagram.

Ans: (See Topic 13.3, Long Question-1)

13.5 Suppose you have a glass rod which becomes positively charged when you rub it with wool. Describe how you would charge the electroscope.

(i) Negatively

(ii) Positively

Ans: (See Topic 13.3, Long Question-1)

13.6. With the help of electroscope how you can find presence of charge on a body.

Ans: (See Topic 13.3, Long Question-1)

13.7. Describe how you would determine the nature of the charge on a body by using electroscope.

Ans: (See Topic 13.3, Long Question-1)

13.8. Explain Coulomb's law of electrostatics and write its mathematical form.

Ans: (See Topic 13.4, Long Question-1)

13.9. What is meant by electric field and electric intensity?

Ans: (See Topic 13.5, Long Question-1)

13.10. Is electric intensity a vector quantity? What will be its direction?

Ans: **TYPE OF QUANTITY**

Electric field intensity is a vector quantity. It has the same direction as that of force acting on the positive test charge. If the test charge is free to move, it will move in the direction of electric intensity.

13.11. How would you define potential difference between two points? Define its unit.

Ans: *Given on Page # 170*

13.12. Show that potential difference can be described as energy transfer per unit charge between the two points.

Ans: **POTENTIAL DIFFERENCE**

Explanation:

A body in gravitational field always tends to move form a point of higher potential energy to a point of lower potential energy. Similarly, when a charge is released in a electric field, it moves form a point of higher potential say A to a point at lower potential say B.

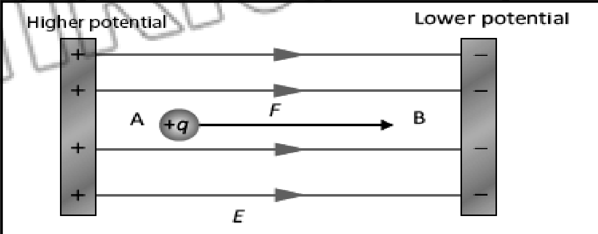


Figure: Potential Difference between Two Points

If the potential of point A is V_a and that of point B is V_b the potential energy of the charge at these points will be qV_a and qV_b respectively. The change in potential energy of the charge when it moves from point A to B will be equal to qV_a-qV_b. This energy is utilized in doing some useful work.

Thus Energy supplied by the charge = $q(V_a-V_b)$

If q is equal to one unit, then the potential difference between two points becomes equal to the energy supplied by the charge.

Conclusion:

Hence, potential difference is the energy transfer per unit charge between the two points.

13.13. What do you mean by the capacitance of a capacitor? Define units of capacitance.

Ans: *Given on Page # 174*

13.14. Derive the formula for the equivalent capacitance for a series combination of a number of capacitors.

Ans: (See Topic 13.7, Long Question-3)

13.15. Discuss different types of capacitors.

Ans: (See Topic 13.8, Long Question-1)

13.16. What is difference between variable and fixed type capacitor? *(K.B)*

Ans: **DIFFERENTIATE**

The difference between variable and fixed type capacitor are:

Fixed Capacitor	Variable Capacitor
Definition	
• A capacitor whose capacitance cannot be changed is called fixed capacitor.	• A capacitor whose capacitance can be changed is called variable capacitor.
Construction	
• It's both plates are immovable.	• It's one sets of plate is fixed and other is movable.
Examples	
• Mica capacitor • Paper capacitor	• Capacitor for the tuning of radio sets

13.17. Enlist some uses of capacitors.

Ans: (See Topic 13.8, Long Question-2)

13.18. Discuss one application of static electricity.

Ans: (See Topic 13.9, Long Question-1)

13.19. What are hazards of static electricity?

Ans: (See Topic 13.10, Long Question-1)

CONCEPTUAL QUESTIONS

13.1 An electrified rod attracts pieces of paper. After a while these pieces fly away! Why?

Ans: **AN ELECTRIFIED ROD AND PIECES OF PAPER**

When a glass rod is rubbed with a silk cloth, it is positively charged. This electrified rod attracts pieces of paper. When the pieces of paper touch the rod, they give up some electrons to the glass rod and become positively charged. They are then flown away by the rod due to force of repulsion form the positive charge remaining on the rod.

13.2 How much negative charge has been removed from a positively charged electroscope if it has a charge of 7.5 x 10^{-11}C?

Ans: **REMOVAL OF NEGATIVE CHARGE**

A charge of -75 $\times$ 10^{-11} C has been removed from a positively charged electroscope which has a charge of 7.5 $\times$ 10^{-11}C.

13.3 In what direction will a positively charged particle move in an electric field?

Ans: **MOVEMENT OF POSITIVE CHARGE**

A positive charge released in an electric field will move along the direction electric field i.e. from higher potential to the lower potential.

13.4 Does each capacitor carry equal charge in series combination? Explain.

Ans: **CHARGE IN SERIES CONBINATION**

As in series combination each capacitor is connected side by side, so each capacitor carries equal magnitude of charge due to electrostatic induction.

13.5 Each capacitor in parallel combination has equal potential difference between its two plates. Justify the statement.

Ans: **POTENTIAL DIFFERENCE IN PARALLEL**

In a parallel combination of capacitors, two plates of each capacitor are connected to the positive and negative terminals of a battery between the same two points. Hence potential difference between two plates of each capacitor is equal i.e equal to the potential difference of the battery.

13.6 Perhaps you have seen a gasoline truck trailing a metal chain beneath it. What purpose does the chain serve?

Ans: *Given on Page # 189*

13.7 If a high-voltage power line fell across your car while you were in the car, why should you not come out of the car?

Ans: *Given on Page # 189*

13.8 Explain why, a glass rod can be charged by rubbing when held by hand but an iron rod cannot be charged by rubbing, if held by hand?

Ans: **CHARGING OF GLASS ROD AND IRON ROD**

Because glass rod is an insulator, so charge developed on it during rubbing does not flow to the ground through the hand holding it. However, iron rod is a conductor and charge developed on it during rubbing can easily flow to the ground through the hand holding it. For this reason all metal objects used in electrostatic have insulating handles or stands.

NUMERICAL PROBLMES *(U.B+A.B)*

13.1 The charge of how many negatively charged particles would be equal to $100\mu C$. Assume charge on one negative particle is $1.6\times10^{-19}C$?

Solution:

Given Data:

Total Charge Q = 100 μC
$= 100 \times 10^{-6}$ C
Charge on an electron=e= 1.6×10^{-19} C

Required:

No. of negatively charged particles n =?

Formula:

$$Q = ne$$

Or $$n = \frac{Q}{e}$$

Calculations:

Putting the values from given data in the formula,

$$n = \frac{100\times10^{-6}C}{1.6\times10^{-19}C}$$
$$= \frac{10^{2}\times10^{-6}\times10^{19}}{1.6}$$
$$= \frac{10^{-6}\times10^{21}}{1.6}$$
$$= \frac{1}{1.6}\times10^{15}$$
$$= \frac{1}{16}\times10^{16} = 0.0625\times10^{16}$$
$$n = 6.25 \times 10^{14} \text{ electrons}$$

Result:

Hence, the wavelength of the radio waves transmitted by an FM station will be 3.33 m.

13.2 Two point charges $q_1 = 10\mu C$ and $q_2 = 5\mu C$ are placed at a distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.

Solution:

Given Data:

First point charge= $q_1 = 10\mu C = 10\times10^{-6} = 1\times10^{-5}C$
Second point charge = q_2 = 5 μC = 5×10^{-6} C
Distance between charges = r = 150 cm = $\frac{150cm}{100}$ = 1.5 m
Proportionality constant = k = 9×10^{9} $Nm^2 C^{-2}$

Required:

(i) Magnitude of Coulomb's force F =?
(ii) Direction of Coulomb's force =?

Formula:

$$F = k\frac{q_1q_2}{r^2}$$

Calculations:

By putting the values from given data in the formula

$$F = \frac{9\times10^{9}Nm^{2}C^{-2}\times1\times10^{-5}C\times5\times10^{-6}C}{(1.5m)^{2}}$$
$$= \frac{9\times10^{9}Nm^{2}\times10^{-5}\times5\times10^{-6}}{2.25m^{2}}$$
$$= \frac{45\times10^{-2}N}{2.25}$$
$$= \frac{45}{225}N$$
$$F = 0.2 N$$

Result:

Hence, coulomb's force between the charges will be 0.2N. Since both charges are positive therefore nature of force will be repulsive.

13.3 The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m part. Find the value of each charge.

Solution:

Given Data:

Force of repulsion = F = 0.8 N

Distance between the charges r = 0.1 m

Proportionality constant = k = 9×10^9 Nm^2C^{-2}

Since the charges are identical, therefore, $q_1 = q_2 = q$

Required:

Value of each charger = q = ?

Formula:

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

Calculations:

Putting the values from given data in the formula.

$$0.8 = \frac{9\times10^9 q\times q}{(0.1)^2}$$

By putting the values

$$q^2 = \frac{0.8\times(0.1)^2}{9\times10^9}$$

$$= \frac{0.8\times0.01}{9\times10^9}$$

$$= 8.83\times10^{-13}$$

Taking square root on both sides

$$q = \sqrt{8.83\times10^{-13}}$$

$$q = 9.4\times10^{-7}\ C$$

Result:

Hence, value of each charge will be 9.4×10^{-7} C.

13.4 Two charges repel each other with a force of 0.1 N when they are 5cm apart. Find the forces between the same charges when they are 2 cm apart.

Solution:

Given Data:

First force of repulsion $=F_1=0.1N$

First distance $=r_1=5cm$

$r_1=0.05m$

Second distance$=r_2=2cm$

$r_2=0.02m$

Required:

Second force of repulsion $=F_2=?$

Formula Used:

$$F_1 = \frac{kq_1q_2}{r_1^2} \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1)}$$

$$F_2 = \frac{kq_1q_2}{r_2^2} \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (2)}$$

Or dividing equation (1 and equation (2)

$$\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2} \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (3)}$$

Calculations:

Putting the values from given data in the formula (3)

$$\frac{0.1N}{F_2} = \frac{0.02^2m^2}{0.05^2m^2}$$

$$F_2 = \frac{0.1\times0.05^2}{0.02^2}$$

$$F_2 = 0.625N$$

Result:

Hence, new force of repulsion between two charges will be 0.625N.

13.5 The potential at a point in an electric field is 10^4 V. If a charge of $+100\mu C$ is brought from infinity to this point. What would be the amount of work done on it?

Solution:

Given Data:

Electric potential=V= 10^4 V

Charge=q= +100 μC

$= 100 \times 10^{-6}$ C $= 1 \times 10^{-4}$ C

Required:

Work done=W =?

Formula:

$$V = \frac{W}{q}$$

Or $W = qV$

Calculations:

Putting the values from given data in the formula.

$$W = 10^{-4}\,C \times 10^{4}\,C$$

$$W = 1J$$

Result:

Hence, the amount of work done on the charge will be 1J.

13.6 A point charge of +2C is transferred from a point at potential 100V to a point at potential 50V, what would be the energy supplied by the charge?

Solution:

Given Data:

Charge= q = +2C

Potential at point A= V_A = 100 V

Potential at point B= V_B = 50 V

To Find:

Energy supplied by the charge E =?

Formula:

$$E = q(V_A - V_B)$$

Calculations:

Putting the values from given data in the formula

$$E = 2C(100V - 50V)$$

$$E = 100\,J$$

Result:

Hence, energy supplied by the charge will be 100J.

13.7 A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Solution:

Given Data:

Charge on a capacitor = Q = 0.06 C

Voltage V = 9V

Required:

Capacitance C = ?

Formula:

$$Q = CV$$

Or $$C = \frac{Q}{v}$$

Calculations:

Putting the values from given data in the formula

$$C = \frac{0.06C}{9v}$$

$$C = 6.67 \times 10^{-3}\ F$$

Result:

Hence, capacitance of the capacitor will be 6.67×10^{-3} F.

13.8 A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge? (LHR 2017)

Solution:

Given Data:

First Charge = Q_1 = 0.03C

First Voltage = V_1 = 6V

Second Charge = Q_2 = 2C

Required:

Second Voltage = V_2 = 6V

Formula:

$$C = \frac{Q_1}{V_1} \qquad (1)$$

$$C = \frac{Q_2}{V_2} \qquad (2)$$

Comparing equation (1) and equation (2)

$$\frac{Q_1}{V_1} = \frac{Q_2}{V_2} \qquad (3)$$

Calculations:

Putting the values from given data in the formula (3)

$$\frac{0.03C}{6V} = \frac{2C}{V_2}$$

$$V_2 = \frac{12V}{0.03}$$

$$V_2 = 400V$$

Result:

Hence, 400 V would be required to hold 2C charge.

13.9 Two capacitors of $6\mu F$ and $12\mu F$ are connected in series with 12V battery. Find the equivalent capacitance of the combination. Find the charge and potential difference across each capacitor.

Solution:

Given Data:

Capacitance = $C_1 = 6\ \mu F = 6 \times 10^{-6}F$
Capacitance = $C_2 = 12\ \mu F = 12 \times 10^{-6}F$
Voltage = V = 12 V

Required:

(i) Equivalent capacitance = C_{eq} =?
(ii) Charge on each capacitor = Q =?
(iii) Potential difference across one capacitor = V_1 =?
Potential difference across second capacitor = V_2 =?

Formula:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{———— (1)}$$

$$Q = CV \quad \text{———— (2)}$$

$$V_1 = \frac{Q}{C_1} \quad \text{———— (3)}$$

$$V_2 = \frac{Q}{C_2} \quad \text{———— (4)}$$

Calculations:

Putting the values from given data in the formula (1).

$$\frac{1}{C_{eq}} = \frac{1}{6\mu F} + \frac{1}{12\mu F}$$

$$\frac{1}{C_{eq}} = \frac{2+1}{12\mu F}$$

$$\frac{1}{C_{eq}} = \frac{3}{12\mu F}$$

$$C_{eq} = \frac{12\mu F}{3}$$

$$C_{eq} = 4\mu F$$

(ii) Putting the values from given data in the formula (2).

$$Q = 4 \times 10^{-6}\ F \times 12V$$

$$Q = 48 \times 10^{-6}\ FV$$

$$Q = 48\ \mu C$$

(iii) Putting the values from given data in the formula (3).

$$V_1 = \frac{48\mu C}{6\mu F} = 8V$$

Putting the values from given data in the formula (4).

$$V_2 = \frac{48\mu C}{12\mu F} = 4V$$

Result:

Hence,

- **Equivalent capacitance of series combination is 4μF.**
- **Charge on each capacitor is 48 μC.**
- **Potential difference across first capacitor is 8V.**
- **Potential difference across second capacitor is 4V.**

13.10 Tow capacitors of capacitances $6\mu F$ and $12\mu F$ are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor. (LHR 2017)

Solution:

Given Data:

Capacitance of first capacitor = C_1 = 6μF
Capacitance of second capacitor = C_2 =12μF
Voltage = V = 12V

Required:

(i) Equivalent capacitance = C_{eq} =?
(ii) Charge on one capacitor = Q_1 =?
(iii) Charge on second capacitor = Q_2 =?
(iv) Potential difference across each capacitor = V =?

Formula:

$C_{eq} = C_1 + C_2$ ______________ (1)
$Q_1 = C_1V$ ______________ (2)
$Q_2 = C_2V$ ______________ (3)

Calculations:

(i) Putting the values from given data in the formula (1)

$C_{eq} = 6\mu F + 12\mu F$
$C_{eq} = 18\mu F$

(ii) Putting the values from given data in the formula (2)

$Q_1 = 6\mu F \times 12V$
$Q_1 = 72\mu C$ **Ans.**

(iii) Putting the values from given data in the formula (3

$Q_2 = 12\ \mu\ F \times 12\ V$
$Q_2 = 144\mu\ C$ Ans.

(iv) Since the capacitors are connected in parallel, therefore, potential difference across each capacitor will be 12V.

Result:

Hence,

- **Equivalent capacitance of parallel combination is 18μF.**
- **Charge on each first capacitor is 72 μC.**
- **Charge on each second capacitor is 144 μC.**
- **Potential difference across each capacitor is 12V.**

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. The value of Coulomb's constant "K" depends upon:
(A) System of units (B) Medium between charges
(C) Quantity of charges (D) Both A & B

2. The unit of electric intensity is:
(A) N (B) C
(C) NC^{-1} (D) NC

3. The equivalent capacitance of a parallel combination of capacitors, than any individual capacitance is:
(A) Smaller (B) Greater
(C) Same (D) None of these

4. The spacing between the field lines shows:
(A) Strength of electric field (B) Direction of Electric field intensity
(C) Both (A) & (B) (D) None of these

5. One coulomb charge has electrons:
(A) 6.25×10^{18} (B) 6.25×10^{15}
(C) 6.25×10^{14} (D) 6.25×10^{19}

6. Electric field lines:
(A) Always cross each other
(B) Never cross each other
(C) Cross each other in the region of strong field
(D) Cross each other in the region of weak field

Q.2 Give short answers to following questions. **(5×2=10)**

i. Define point charges.
ii. Write any three characteristics of charges.
iii. When a 10 µC charge is placed at a point, a force of 10^{-4} N acts on it. Find the amount of electric intensity at this point?
iv. Connect three capacitors in series and draw their circuit diagram.
v. In what direction will a positively charged particle move in an electric field?

Q.3 Answer the following questions in detail. **(4+5=9)**

a) How capacitors are connected in parallel combination, Also describe the characteristic features of this combination.
b) The force of repulsion between two identical positive charges is 0.8N, when the charges are 0.1m apart. Find the value of each charge?

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.