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"What one man calls God, another calls the laws of physics."

-Nikola Tesla

## TOPIC 16: STATIC ELECTRICITY





### CHAPTER ANALYSIS



TIME

- Couple of key concepts to understand
- Difficulty lies in the application and drawing of the electric field lines



• Study application of electrostatic



EXAM

- Light-medium overall weightage
- Constitute to around **3.5%** of marks for past 5 year papers



### ELECTRIC CHARGE CHARGING INSULATORS CHARGING CONDUCTORS







**HOW CHARGES BEHAVE** 

A neutral body has equal amount of positive and negative charge.

When a neutral object is brought close to a charged object, attraction occurs. (Induced charges)



If the neutral object touches the charged object, electrons will flow to the positive charged object and cause both objects to be positively charged. They then repel each other.

LAW OF ELECTROSTATICS

Positive charges

repel

Unlike charges attract and like charges repel.

SI unit for charge is coulomb (C).





\*Please note that this can only occur for conductors, where electrons are free to move.

metal sphere

**Negative charges** repel

Unlike charges attract



### **CHARGING INSULATORS**



#### **RUBBING / FRICTION**

When rubbed with another material, electrons are transferred from one material to another.



#### LAW OF CONSERVATION OF CHARGE

Take note that during this entire process, charges are only transferred from one object to another and charges are neither created nor destroyed.

As electrons are transferred to the amber rod through friction, the rod now has more negative charges than positive charges. Hence, it is negative charged.

The fur has lesser negative charges than positive charges, hence it is positively charged.

### **TAKE NOTE!**

In any charging process, **only the electrons (negative charges) can be transferred.** 

Charging by rubbing **does not work for conductors**, as conductors can transfer excess charges to the hand holding it.

However, electrons in insulators are not free to move about, therefore charges stay after the rubbing process.



### **CHARGING CONDUCTORS**



#### **INDUCTION**

Using an external charged object to induce a charge in conductors.

### **INDUCTION**

- 1) Put 2 neutral metal spheres side by side, in contact with one another.
- 2) Use a negative rod and place it near Sphere A, without actually touching it.
- 3) Since like charges repel and unlike charges attract, electrons in Sphere A will travel away to Sphere B. This will result in an uneven charge distribution as seen in the diagram where Sphere A has more positive charges while Sphere B has more negative charges.
- 4) While keeping the negative rod near Sphere A, separate both the spheres. When they are no longer in contact and electrons are not free to move within the spheres, remove the negative rod.

### **TAKE NOTE!**

**Induction only works for conductors and not insulators** as electrons are free to move in conductors.





### **CHARGING CONDUCTORS**



#### **INDUCTION + EARTHING**

Inducing charges on a single sphere, then earthing the sphere such that electrons are transferred to/from the ground and only the induced charges remain.



#### **INDUCTION + EARTHING**

- 1) Use a negative rod and place it near the sphere, without actually touching it.
- 2) Since like charges repel and unlike charges attract, electrons will be repelled and move the side B, leaving the positive charges in Side A.
- 3) The sphere is then earthed with a finger touching side B, with the negative rod still in place. Electrons will flow from the sphere to the ground and making side B neutral.
- 4) While keeping the negative rod at side A, remove the finger. The sphere is now left with a positive charge.

#### **TAKE NOTE!**

**Induction+ Earthing only works for conductors and not insulators** as electrons are free to move in conductors.



### **CHARGING CONDUCTORS**



Electrons will flow into the metal sphere

They are both positively They repel each other. charged now.

### **CHARGE BY CONTACT**

A very direct way of charging by making a direct physical contact to facilitate the transfer of charges.



### **CHARGE BY CONTACT**

- 1) A positively charged sphere comes in contact with the neutral metal ball.
- 2) Upon contact, the electrons will flow from the neutral metal ball to neutralise the positively charged metal sphere.
- 3) Separate both the objects. Both objects are now positively charged although the sphere now is less positively charged than before.

### TAKE NOTE!

The sphere has to be on a insulating stand if not it will be earthed.

No fingers should come in contact with the charged object at any point as well. (the metal ball is hanged using a string.)

# DISCHARGING



#### **DISCHARGING INSULATORS**

1) **Expose to a flame**, thermal energy from the flame ionises the air particles to produce negative and positive ions, which will discharge an object.

*2)* **Expose to moisture**, in moist conditions, water vapour in the air removes excess charges.

#### **DISCHARGING CONDUCTORS**

1) **Earthing**, connect the object to the ground (earth) with a conducting wire or by touching it with a finger.



### ELECTRIC FIELD BETWEEN POINT CHARGES ELECTROSTATIC HAZARD APPLICATION OF ELECTROSTATIC





### **ELECTRIC FIELD LINES**





### **ELECTRIC FIELD**

A region in which an electric charge experiences a force.

#### **ELECTRIC FIELD LINE**

It is the path a positive charge will take. The direction of an electric field like follows the path of a positive charge.







#### NOTE THAT:

- Field lines should never cross
- Always from positive to negative
- Distance between field lines represent strength of electric field (stronger inside than outside)







### **ELECTROSTATIC HAZARDS**





#### **BUILD UP OF CHARGES DUE TO FRICTION**

Friction can cause a large buildup of charge that can cause sparks.

Friction between road and moving vehicle: The tyres of a moving truck rub against the surface of the road and electric charges accumulate on the truck.

When there is a sudden discharge, sparks produced can ignite highly flammable load and cause an explosion.

Prevention:

- Hang a metal chain that can allow the discharge of any excess charges
- Use synthetic rubber tyres that contain carbon which can discharge excess charges

### **FORMATION OF LIGHTNING**

Thunderclouds become charged when water molecules collide with air particles. Electrons collect at the bottom of the clouds and when the accumulation is big enough, the ionized air particles form a conducting path for the charges to be discharged to the ground.

Prevention:

- Lightning conductors are placed onto of tall structures and buildings to provide a conducting path for the electrons discharged.



### APPLICATION OF ELECTROSTATIC





paper

### **PHOTOCOPIER**

The inside a photocopier is a drum coated with a thin layer of selenium.

Photocopier makes use of selenium, a photoconductor - conductor under light, insulator in the dark.

### <u>How it works</u>

1. Whole surface of the drum is charged positively by rotating it near a highly charged metal wire

2. When a printed page is to be photocopied, light is reflected off the page and projected onto the drum.

White parts of the page reflect intense light to some parts of the drum and these areas become conducting and lose their charge.

Other parts of the page do not receive light and these areas on the drum remain insulating and retains their charge.

3. Drum ends up with a pattern of a charge area which is an exact copy of the pattern of printing on the original page.

4. Particles of negatively charged carbon powder (toner) is attracted to the charged areas of the drum.

5. Toner is transferred onto the photocopy as the drum rotates and presses against the copy paper; heat is supplied to melt the toner powder and fix it onto the paper surface.



### APPLICATION OF ELECTROSTATIC



#### **SPRAY PAINTING**

Gives an even coating of an object (car), ensuring that the paint reaches even the most inaccessible parts.



### SPRAY PAINTING

- 1. Paint droplets from an aerosol becomes charged by rubbing against the nozzle of the spray
- 2. The car's body is earthed
- 3. Charged paint droplets will be attracted onto the metal body
- 4. Droplets all have the same charge and repel each other, spreading out evenly throughout the sprayed surface





### APPLICATION OF ELECTROSTATIC





#### **PRECIPITATOR**

Clean smoke coming out from industrial chimneys, by removing fine ash and other particles from waste gases using electrostatic.

### **HOW IT WORKS**

Consists of 2 flat metal plates with a number of metal rods running vertically between them.

- 1. Plates are earthed but rods between are kept strongly negatively charged.
- 2. Strong electric field in the region between the rods and the plates.
- 3. Air molecules around the rods will be ionised due to the strong electric field.
- 4. Positive ions are attracted back to the rods while negative ions are picked up by the tiny particles of ash and dust.
- 5. Charged dust particles then move towards metal plates where they are collected and eventually removed.

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