Static Electricity

Laws of electrostatics

Principles of electrostatics

Applications of electrostatics

Laws of electrostatics

Describe experiments to show electrostatic charging by friction.

Charging by Friction

- **Apparatus:**
  - Plastic straw
  - Tissue paper &
  - A4 paper.
- **Procedure:**
  - Tear off several bits of paper about the size of a pea or smaller and place them on a table or counter. Bring the straw near to the paper bits. What happens?
  - Rub the tissue to the straw and again bring the comb near the bits of paper. What happens now?

- **What Happened:**
  - The first time you brought the straw near the paper bits, nothing happened, but when you rub the straw with a tissue, you gave the straw a charge of static electricity
  - Then, when you brought the straw near the paper bits, they were attracted to the straw because of this charge.

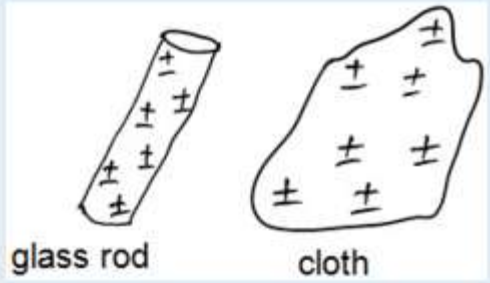
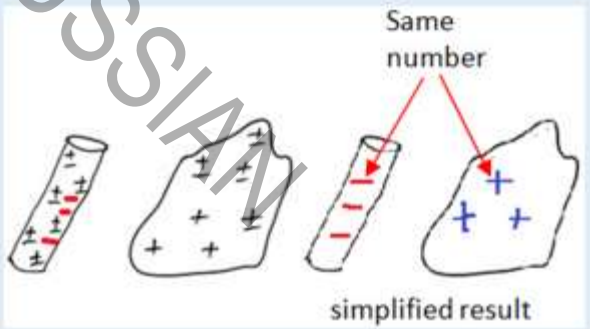
- **Materials Needed:**
  - Plastic straw
  - Tissue paper
  - Faucet.
- **Procedure:**
  - Just barely open a water faucet so that you get a very fine stream of water flowing.
  - Then, rub the straw with the tissue. Slowly bring the comb near the stream of water. What do you see?

Laws of electrostatics

Explain that charging of solids involves a movement of electrons.

Charging by Friction

- When charged is transferred from one object to another, it is generally due to the movement of electrons.

Before rubbing	Rubbing	After rubbing
		
Both are electrically neutral. i.e same number of electrons and positive charges.	Electrons are transferred from cloth to glass rod	Glass rod has excess electrons => negatively charged, Cloth has excess positive charges => positively charged

Laws of electrostatics

State that there are positive and negative charges and that charge is measured in coulombs.

Type of Charges

- Benjamin Franklin discovered that there are two types of electrical charges, **positive** and **negative** charge.

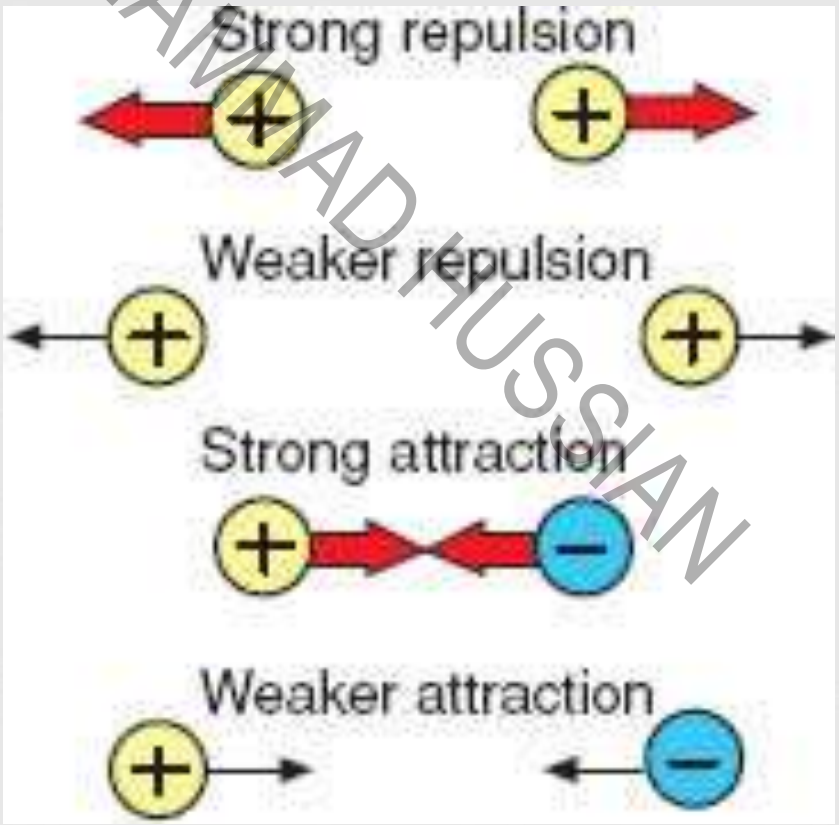
- The SI unit of electric charge is the **coulomb** (**C**).

Laws of electrostatics

State that unlike charges attract and like charges repel.

Law of Charges

- Observations show that charges exert forces on one another over a distance.
- These forces are equal and opposite and become weaker when the distance increases.
- When two charged objects are brought together, they produce either attractive or repulsive forces.
- The observation leads us to a simple principle, called the **law of charges**:
  - Like charges repel and unlike charges attract

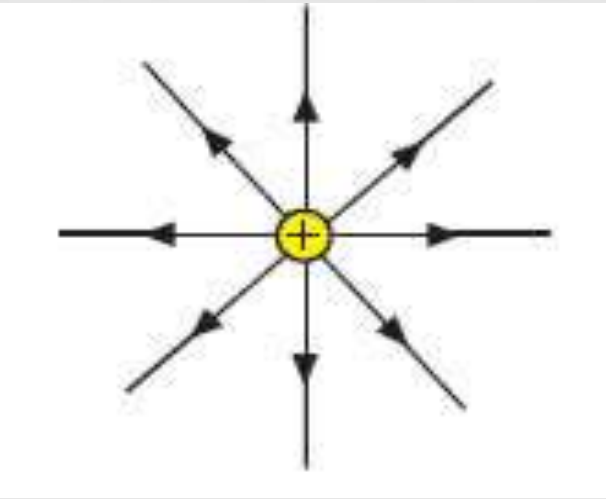


Laws of electrostatics

Describe an electric field as a region in which an electric charge experiences a force.

Electric Field

- An electric field is a region in which an electric charge experiences a force.
- An electric field line is the path a positive charge would take if it is free to move.

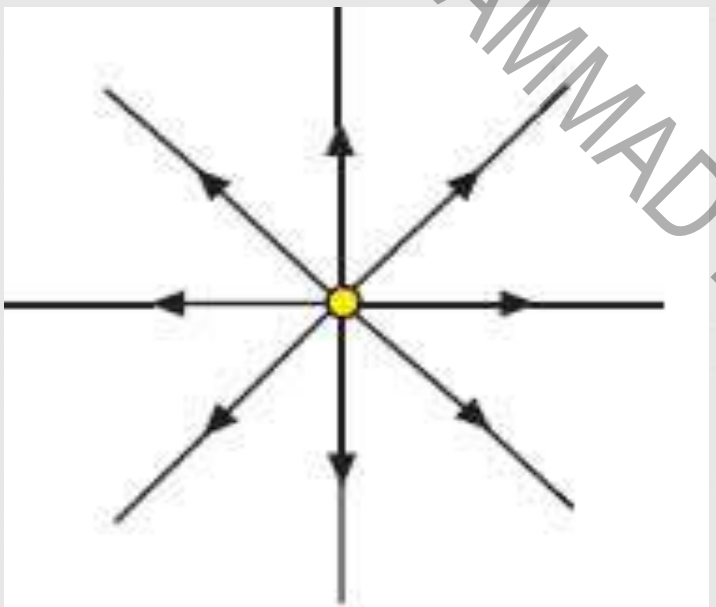


Laws of electrostatics

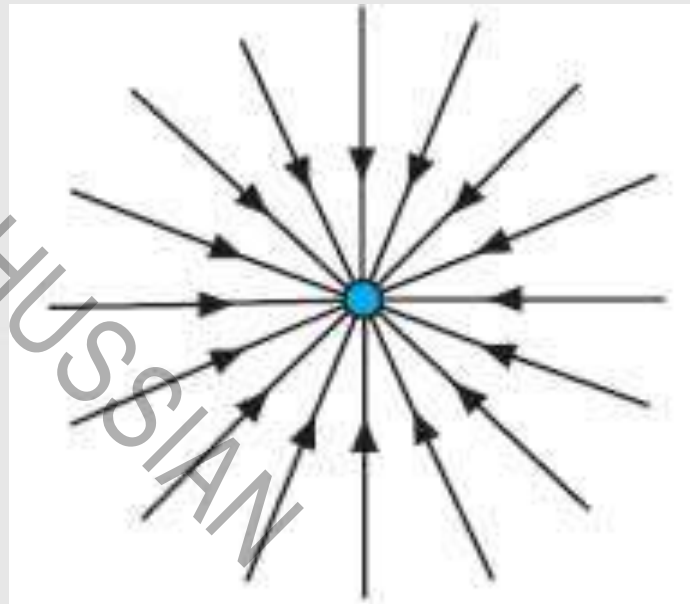
State the direction of lines of force and describe simple field patterns.

Electric Field Lines

- The direction of the electric field lines gives the direction of the force acting on a positive test charge.
- To sketch the combined electric field, the electric lines of force are drawn by following the rules below:
  - The lines must begin from positive charges and end on negative charges.
  - The number of lines drawn leaving a positive chare or ending on a negative charge is proportional to the magnitude of the charge.
  - No two field lines can cross each other.

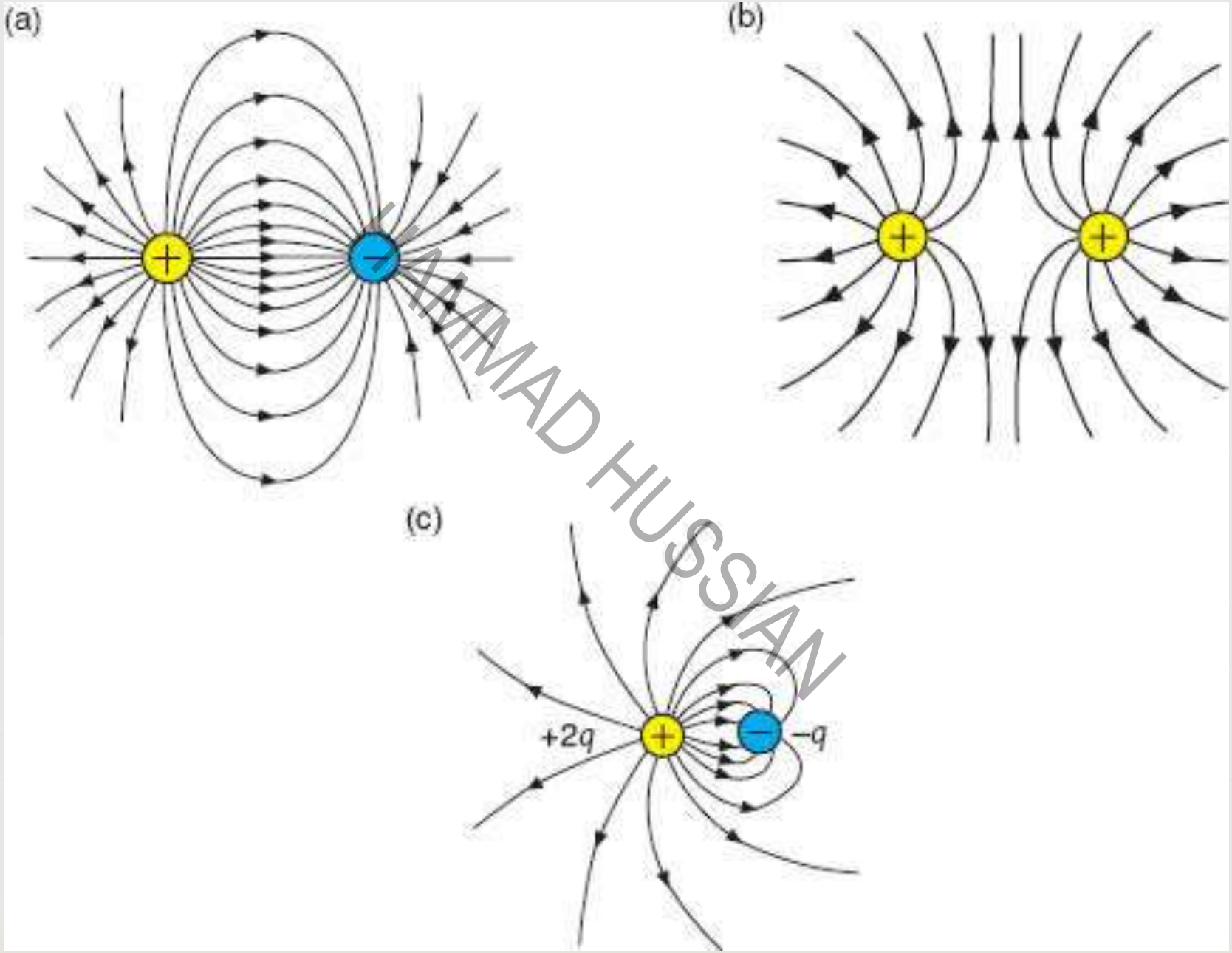


(a) Electric field lines around $+q$

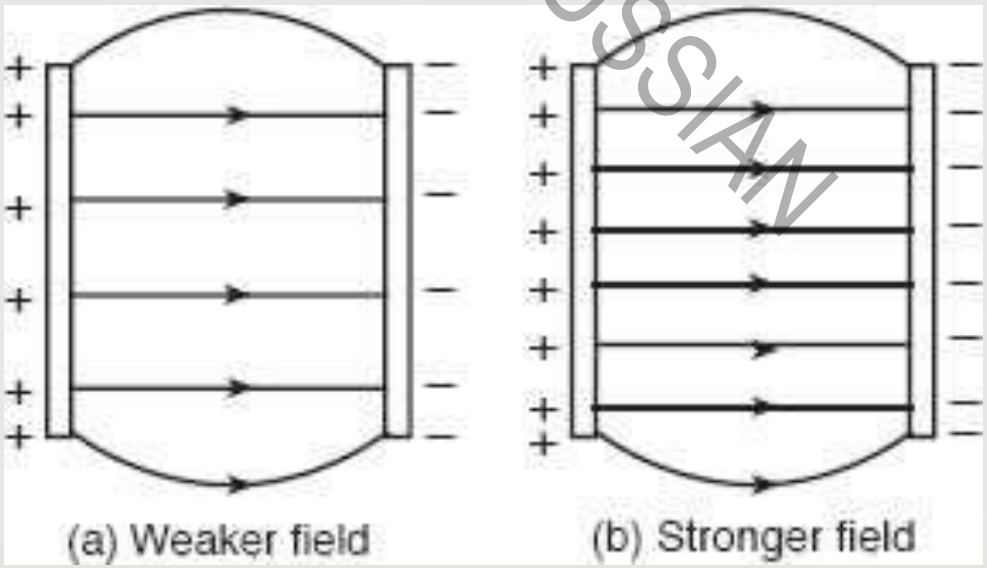


(a) Electric field lines around $-2q$

The number of field lines is proportional to the charge



- The electric field between two parallel oppositely charged plates is uniform at the central region.
- The electric lines of force are closer to each other in a stronger electric field.

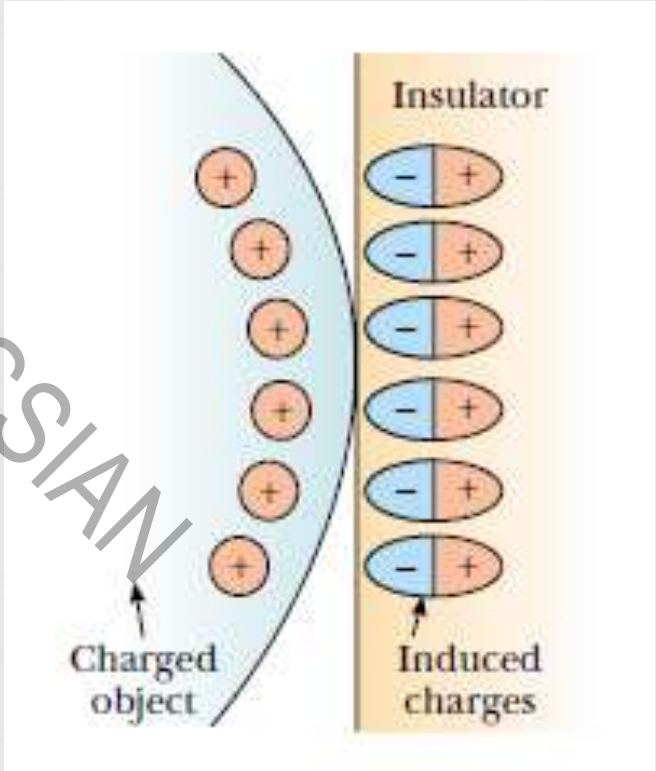


Principles of Electrostatics

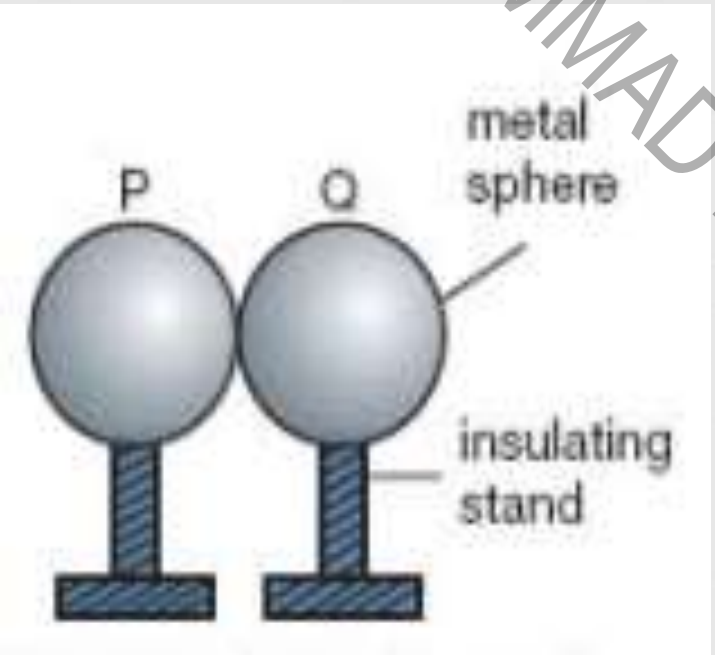
*D*escribe the separation of charges by induction.

Charging by Induction

- Induction is the production of electric charge on the surface of a conductor under the influence of an electric field.
- The advantage of charging by induction is that it can be repeated many times without any loss of charge form the inducing specimen like the negatively charged rod .

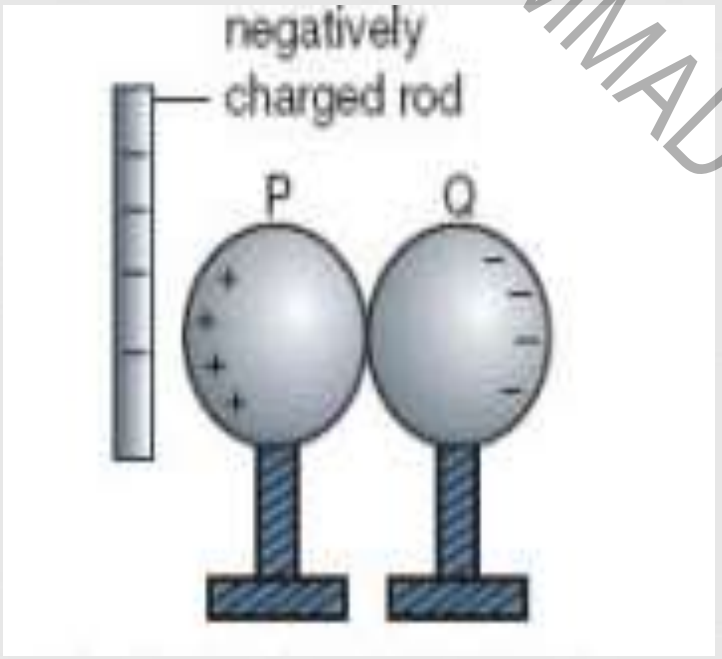


Induction



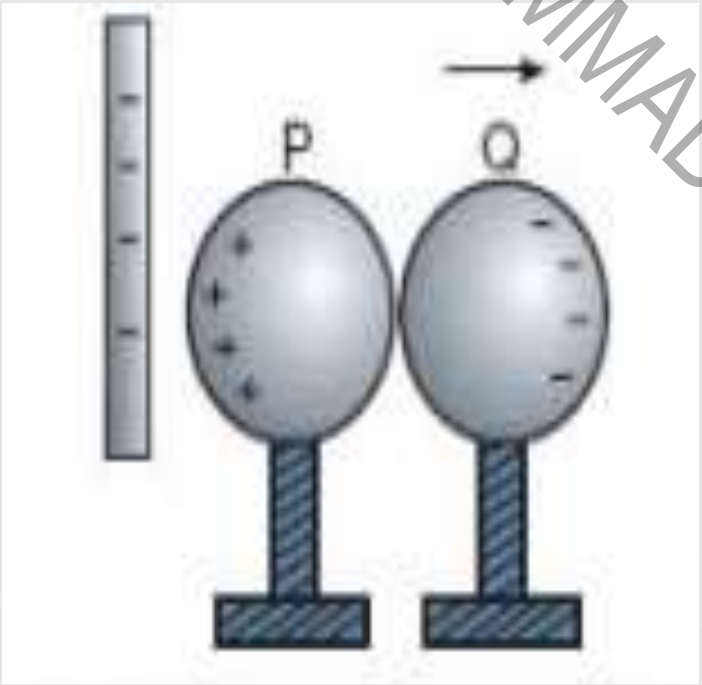
- P and Q are in contact

Induction



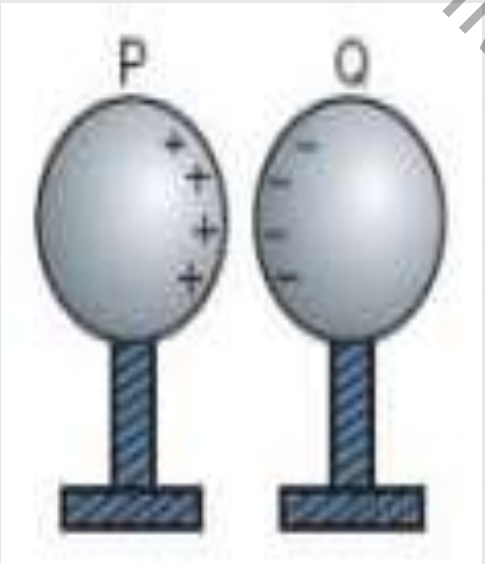
- Charges are induced on P and Q.
- Electrons from P are repelled onto Q

Induction



- P and Q are separated on the presence of the rod.

Induction



- Rod is removed.
- P and Q acquire opposite charges

Principles of Electrostatics

Discuss the differences between electrical conductors and insulators and state examples of each.

Conductors & Insulators

- The behavior of an object which has been charged is dependent upon whether the object is made of a conductive or a nonconductive material.
- Conductors are materials which permit electrons to flow freely from atom to atom and molecule to molecule.
- An object made of a conducting material will permit charge to be transferred across the entire surface of the object.

- Insulators are materials which impede the free flow of electrons from atom to atom and molecule to molecule.
- The particles of the insulator do not permit the free flow of electrons; subsequently charge is seldom distributed evenly across the surface of an insulator.

Conductors	Insulators
Metals	Plastics
Aqueous Solution of Salts	Glass
Graphite	Paper
Water	Rubber
Human Body	Dry air

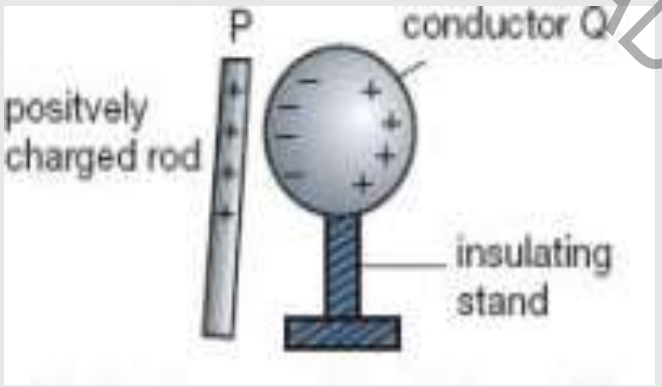
Principles of Electrostatics

State what is meant by *"earthing"* a charged object.

Earthing

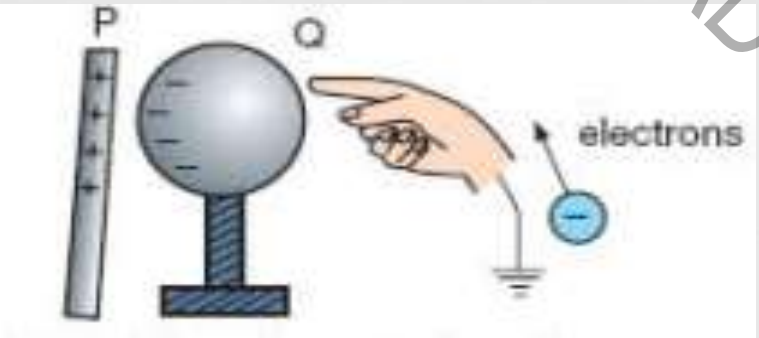
- Earthing or grounding means making objects neutral or uncharged.
- If object is negatively charged than taking its electrons or if it is positively charged than make it gain electrons.

Negatively Sphere



- When a positively charged rod is brought near conductor Q, electrons are attracted to end P.

Negatively Sphere

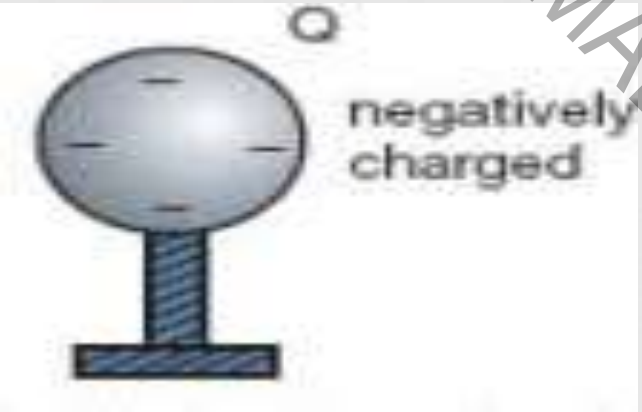


- Earthing allows electrons to flow from the Earth to neutralise positive charge at Q

Negatively Sphere

- Earth is taken away from the conductor

Negatively Sphere

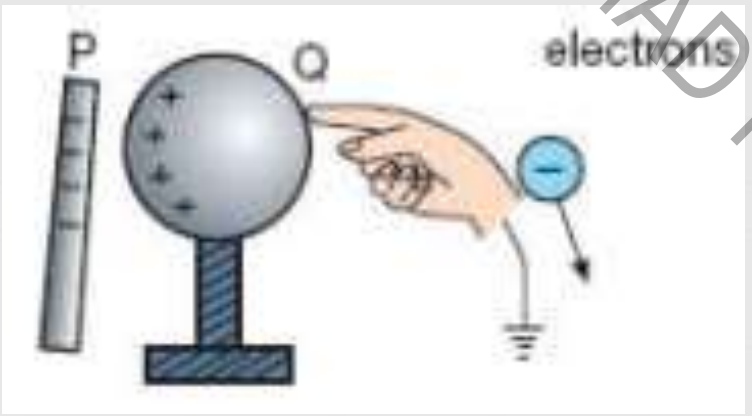


- Positively charged rod is then removed

Positively Sphere

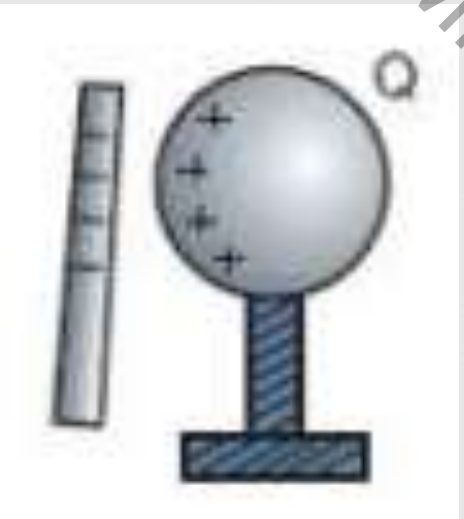
- As a negatively charge rod is brought near to the conductor, electrons are repelled to end Q

Positively Sphere



- Electrons are repelled to the Earth by the rod through earthing

Positively Sphere



- Earthing is removed from the conductor

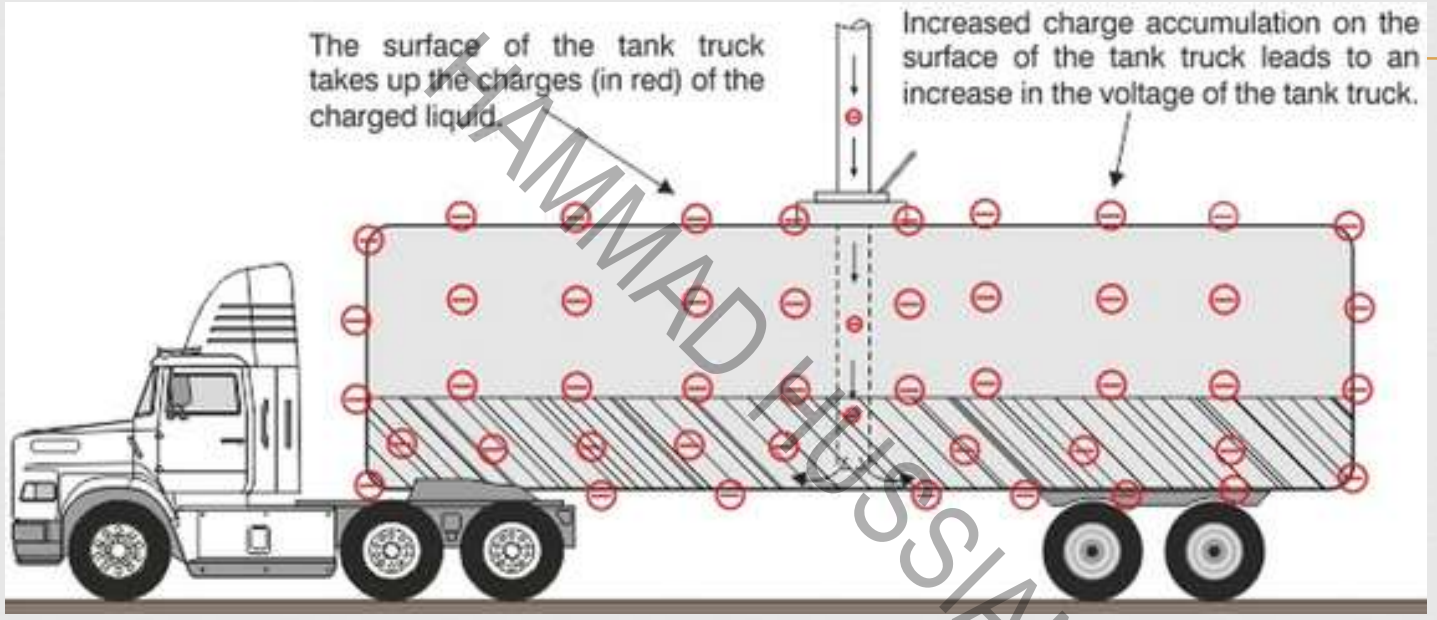
Positively Sphere

- Negatively-charged rod is then removed

Applications of Electrostatics

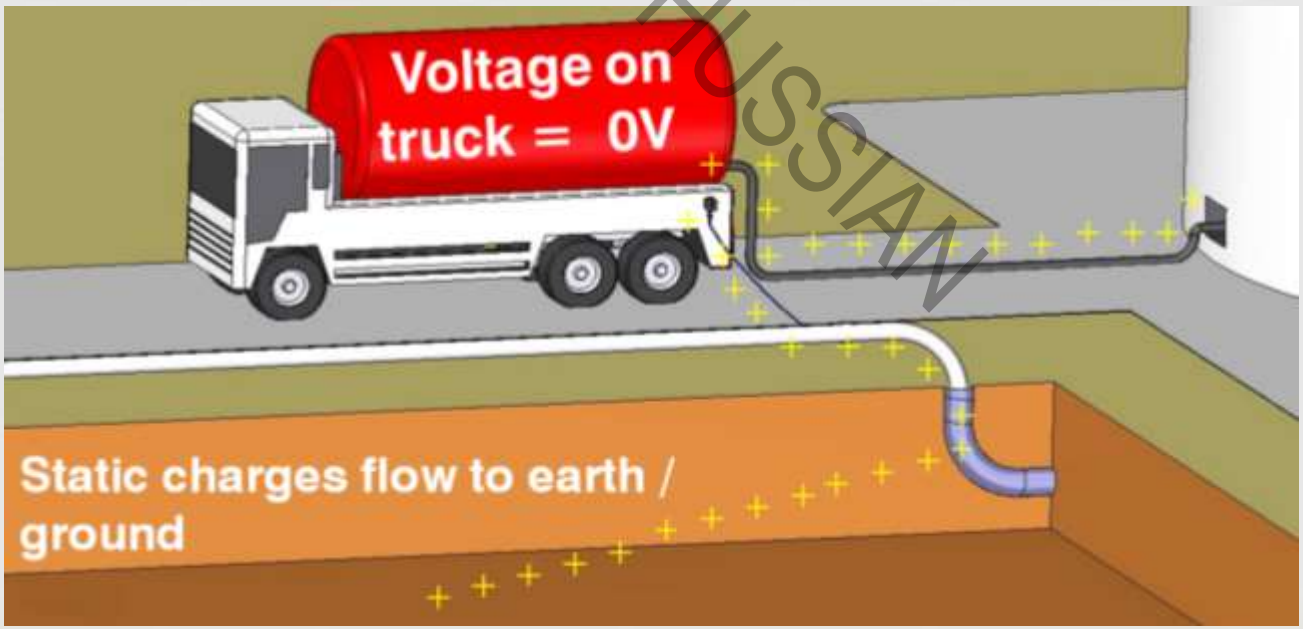
*D*escribe examples where charging could be a problem, e.g. lightning.

Electrostatic Spark

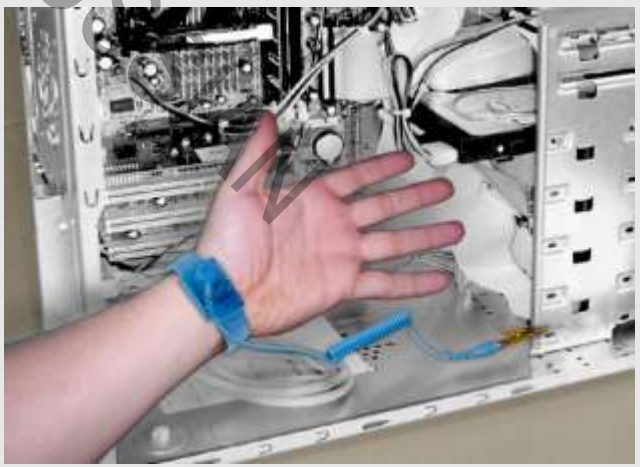


- Electric charges can accumulate on trucks due to **friction between road and tyres of truck**. Sparks may be produced when discharging happens. This will cause any flammable materials that the trucks are carrying to catch fire or explode.

- Connect a **metal chain** at the rear end of truck to the ground to provide a discharging path for excess charges.

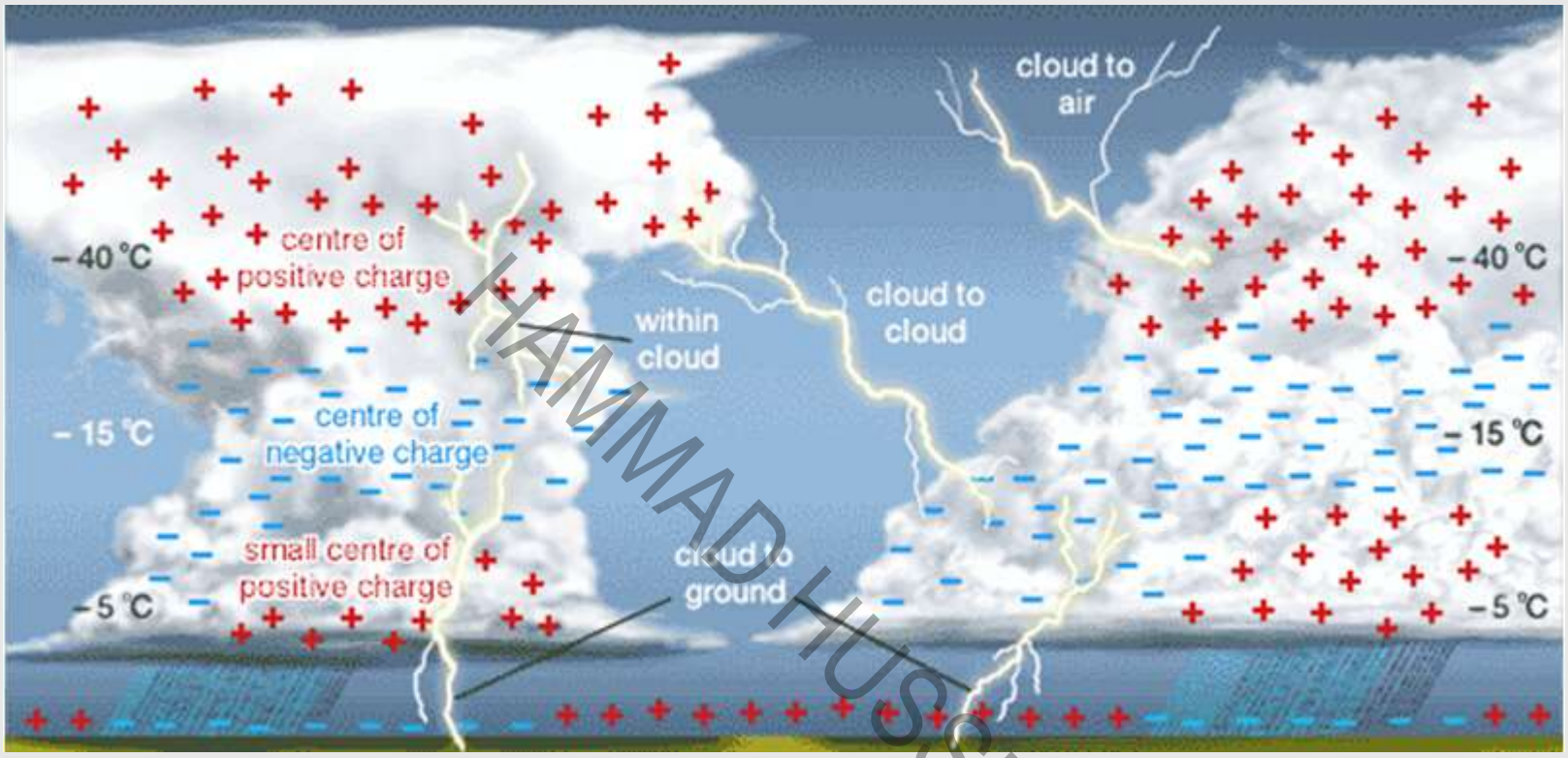


- Charges can be harmful for sensitive electronic equipment including computers.
- A build-up of static charge will result to damaging sparks.



Lightning

- As the negative charges collect at the bottom of the cloud it forces the negative charges in the ground to be forced away from the surface. This leaves the ground positive.
- A streamer of negative charges is repelled by the bottom of the cloud and attracted by the ground.
- As this streamer of negative charges approaches the ground, a streamer of positive charges is repelled by the ground and attracted to the negative streamer.
- When the two streamers connect, they have created a fairly conductive path which allows a sudden down surge of electrons to jump to the ground. This is the lightning.



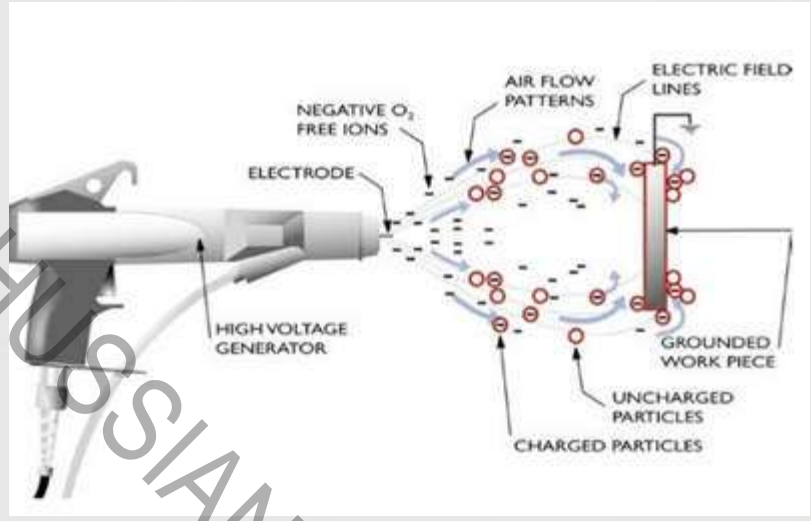
- Lightning conductors are fitted on top of tall buildings to provide a discharge path for excessive electrons in the air to flow from the top of the building into earth.

Applications of Electrostatics

Describe examples where charging is helpful, e.g. photocopier and electrostatic precipitator.

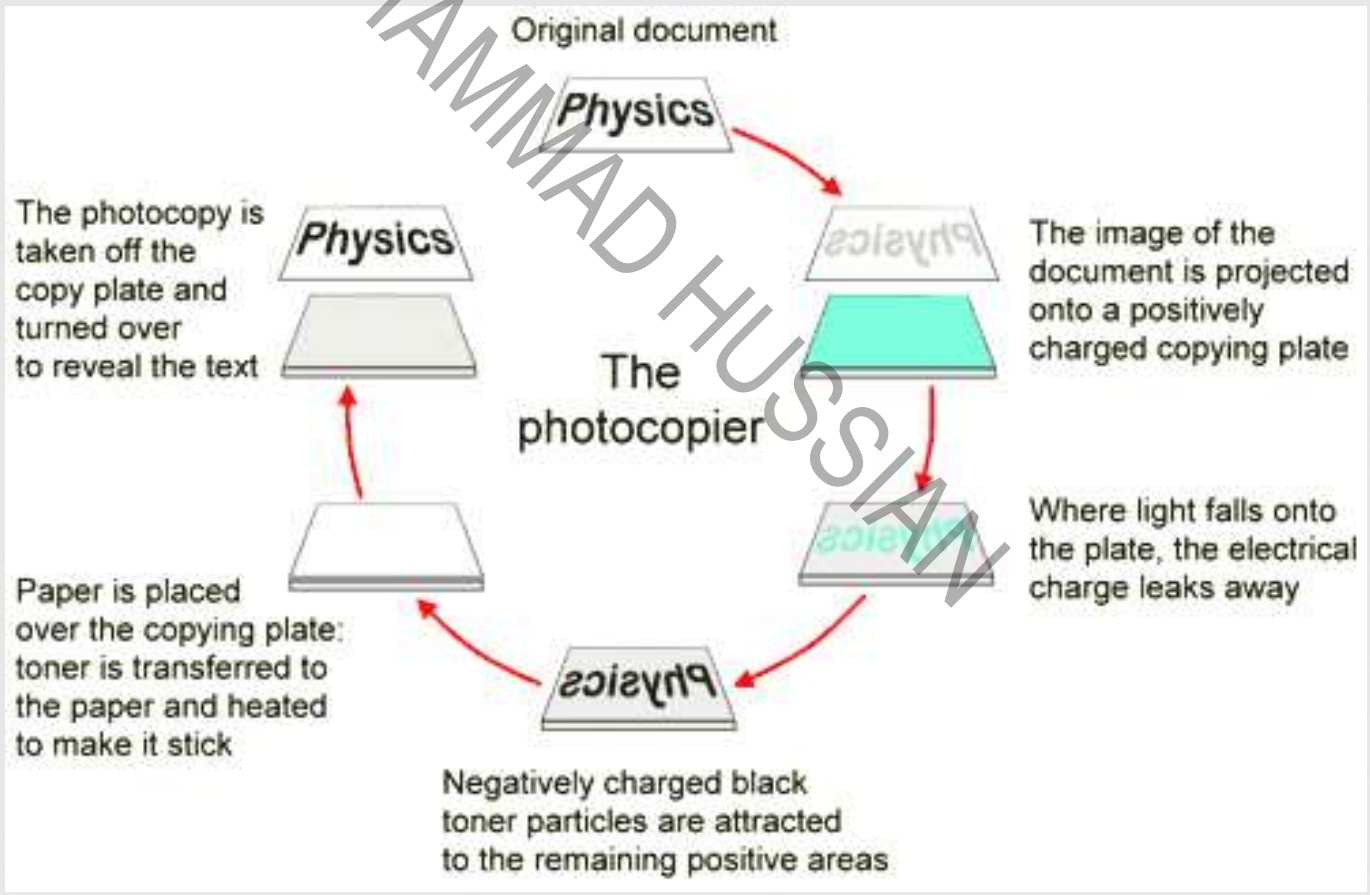
Electrostatic Paint

The nozzle is given a same charge that will repel each other so that the paint spreads out to form a large cloud.

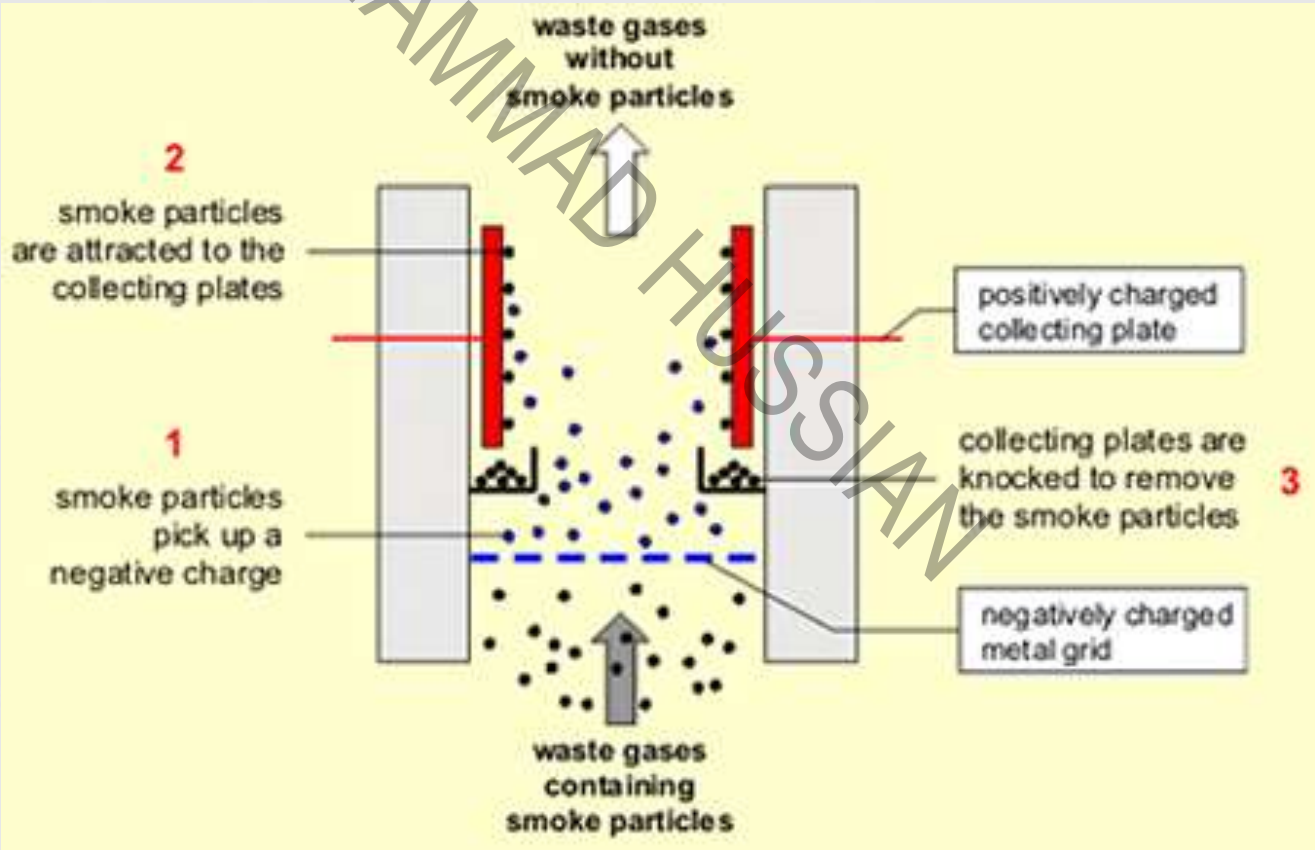


The charged droplets are all attracted to the object because it has an opposite charge.

Photocopy Machine



Electrostatic Precipitator



1. A plastic rod is rubbed with a dry cloth and becomes positively charged.
2. Why has the rod become positively charged?
   A. It has gained electrons.
   B. It has gained neutrons.
   C. It has lost electrons.
   D. It has lost neutrons.

2. A perspex rod can be charged positively by rubbing it with a woollen cloth.
3. How does the rod gain its charge?
   A. The rod gains electrons.
   B. The rod gains protons.
   C. The rod loses electrons.
   D. The rod loses protons.

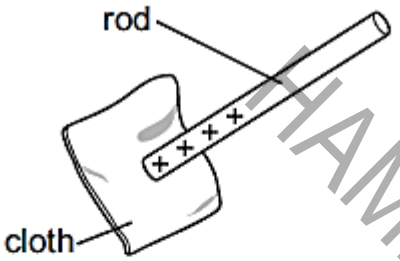
3. A piece of polythene is rubbed with a cloth duster. The polythene becomes negatively charged and the cloth becomes positively charged.
4. What happens to the polythene and to the cloth to cause this?

	polythene	cloth
A	gains electrons	gains protons
B	gains electrons	loses electrons
C	loses protons	gains protons
D	loses protons	loses electrons

B

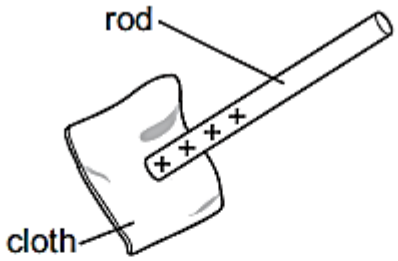
4. In an electrostatics experiment, a plastic rod is rubbed with a cloth. The cloth becomes negatively charged.
5. Which diagram shows the charge on the rod, and describes the movement of charge?

A



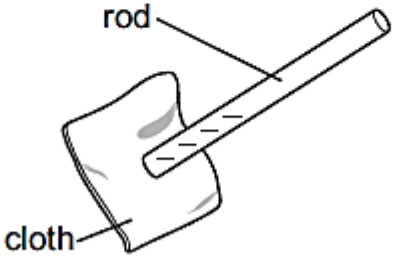
electrons move from the rod onto the cloth

B



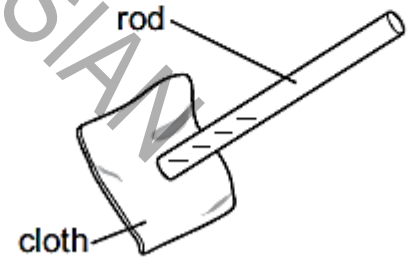
protons move from the cloth onto the rod

C



electrons move from the cloth onto the rod

D



protons move from the rod onto the cloth

A

5. When a plastic comb is placed next to a small piece of aluminium foil hanging from a nylon thread, the foil is repelled by the comb.
6. Why is this?
   A. The comb is charged and the foil is uncharged.
   B. The comb is uncharged and the foil is charged.
   C. The comb and the foil have charge of opposite signs.
   D. The comb and the foil have charge of the same sign.

6. A polythene rod repels an inflated balloon hanging from a nylon thread.
7. What charges must the rod and the balloon carry?
   A. The rod and the balloon carry opposite charges.
   B. The rod and the balloon carry like charges.
   C. The rod is charged but the balloon is not.
   D. The balloon is charged but the rod is not.

7. A negatively-charged balloon is brought towards a wall.
8. Which statement explains what happens?
   A. Negative charges on the balloon attract the negative charges in the wall.
   B. Negative charges on the balloon have no effect on the charges in the wall.
   C. Negative charges on the balloon repel the negative charges in the wall.
   D. Negative charges on the balloon repel the positive charges in the wall.

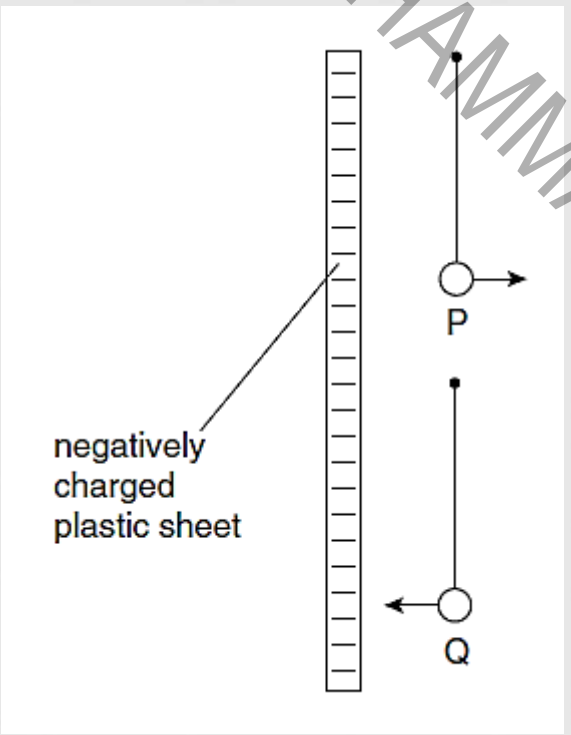
8. The diagram shows a positively charged acetate strip and a negatively charged polythene strip that are freely suspended.

1. Two rods X and Y are brought up in turn to these two strips. Rod X attracts the acetate strip but repels the polythene strip. Rod Y does not repel either the acetate strip or the polythene strip.
2. Which type of charge is on each rod?

	rod **X**	rod **Y**
A	negative	positive
B	negative	uncharged
C	positive	negative
D	positive	uncharged

B

9. Two very light, charged balls P and Q are hung, one above the other, from nylon threads. When a negatively charged plastic sheet is placed alongside them, P is repelled and Q is attracted.

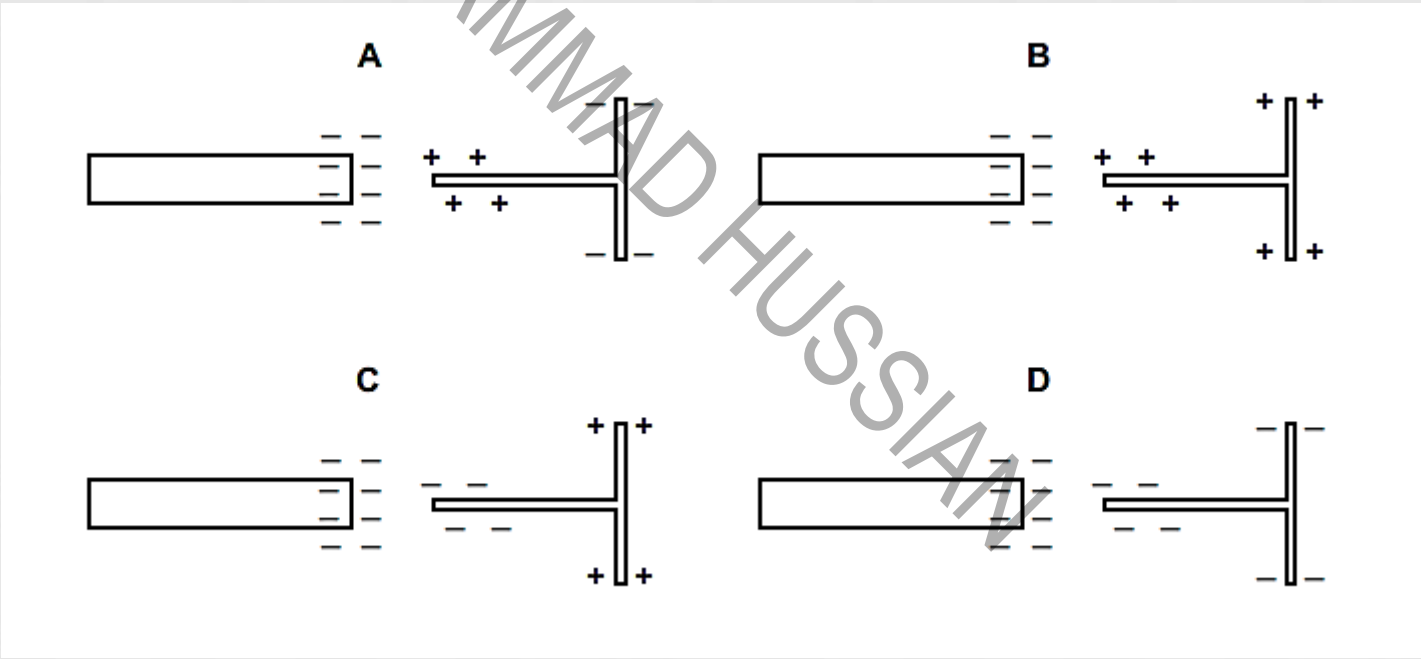


What are the original charges on P and on Q?

	charge on P	charge on Q
A	negative	negative
B	negative	positive
C	positive	negative
D	positive	positive

B

10. A negatively-charged rod is brought close to an isolated T-shaped piece of metal.
11. Initially, the metal is uncharged.
12. Which diagram shows the induced charge on the metal?



A

11. Four processes are used to charge an isolated metal sphere.

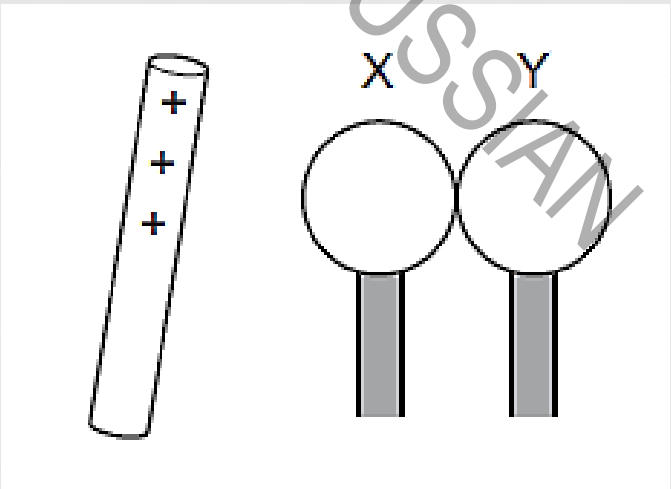
P	The sphere is earthed by touching it.
Q	The earth connection is removed from the sphere.
R	A charged rod is brought close to the sphere.
S	The charged rod is removed.

1. In which order should these processes be carried out to charge the sphere?

	first → last			
A	P	Q	R	S
B	P	R	S	Q
C	R	P	Q	S
D	R	S	P	Q

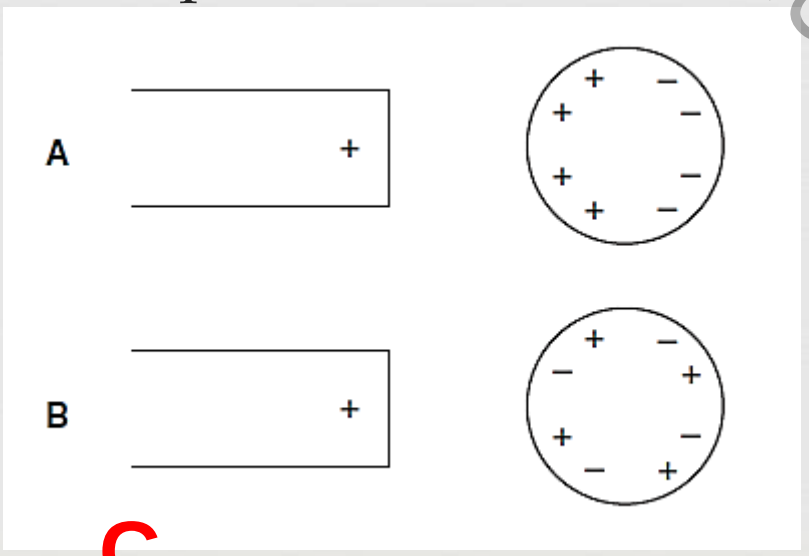
C

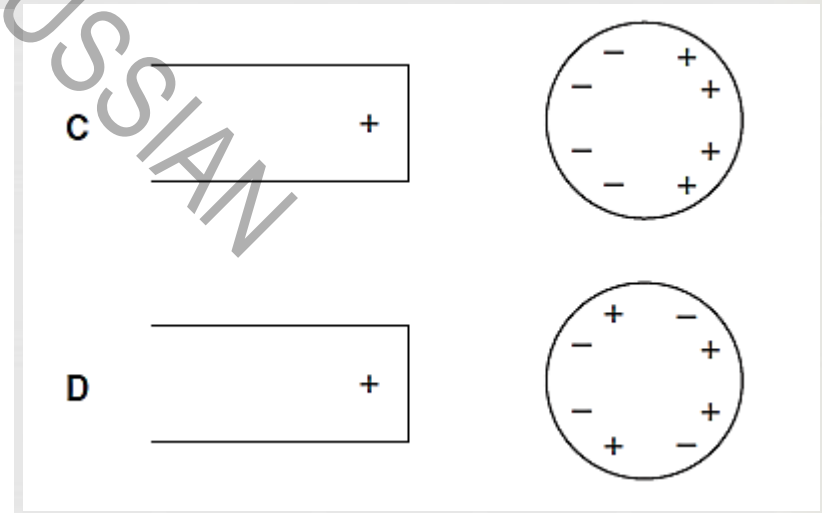
12. Two insulated and uncharged metal spheres X and Y are touching. While a positively charged rod is near X, the spheres are moved apart. After this action, X has a negative charge.



1. What will be the charge on Y?
   A. negative and smaller than that on X
   B. negative and the same size as that on X
   C. positive and smaller than that on X
   D. positive and the same size as that on X

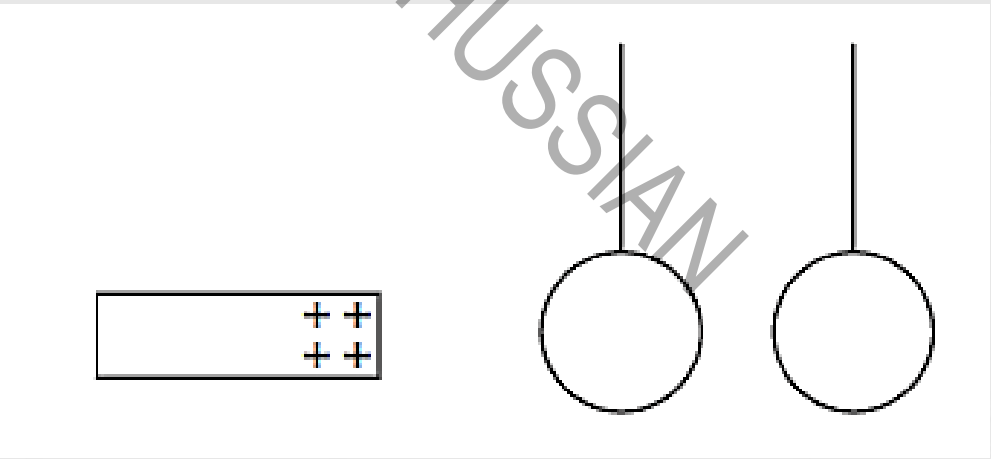
13. A positively charged rod is brought close to an insulated metal sphere.
14. Which diagram best shows the induced charges on the sphere?



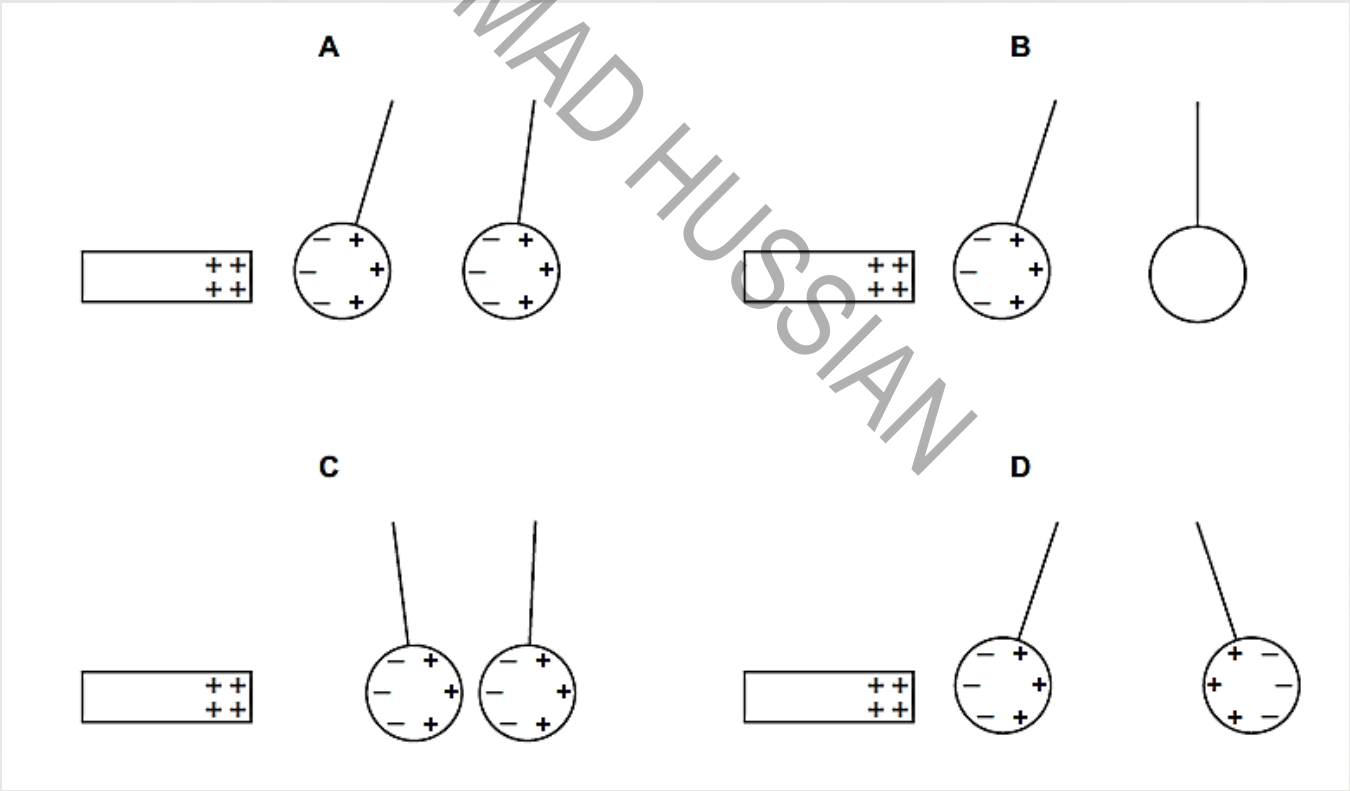


C

14. Two uncharged metal spheres, not touching one another, are suspended by means of cotton thread. A positively charged rod is brought near.

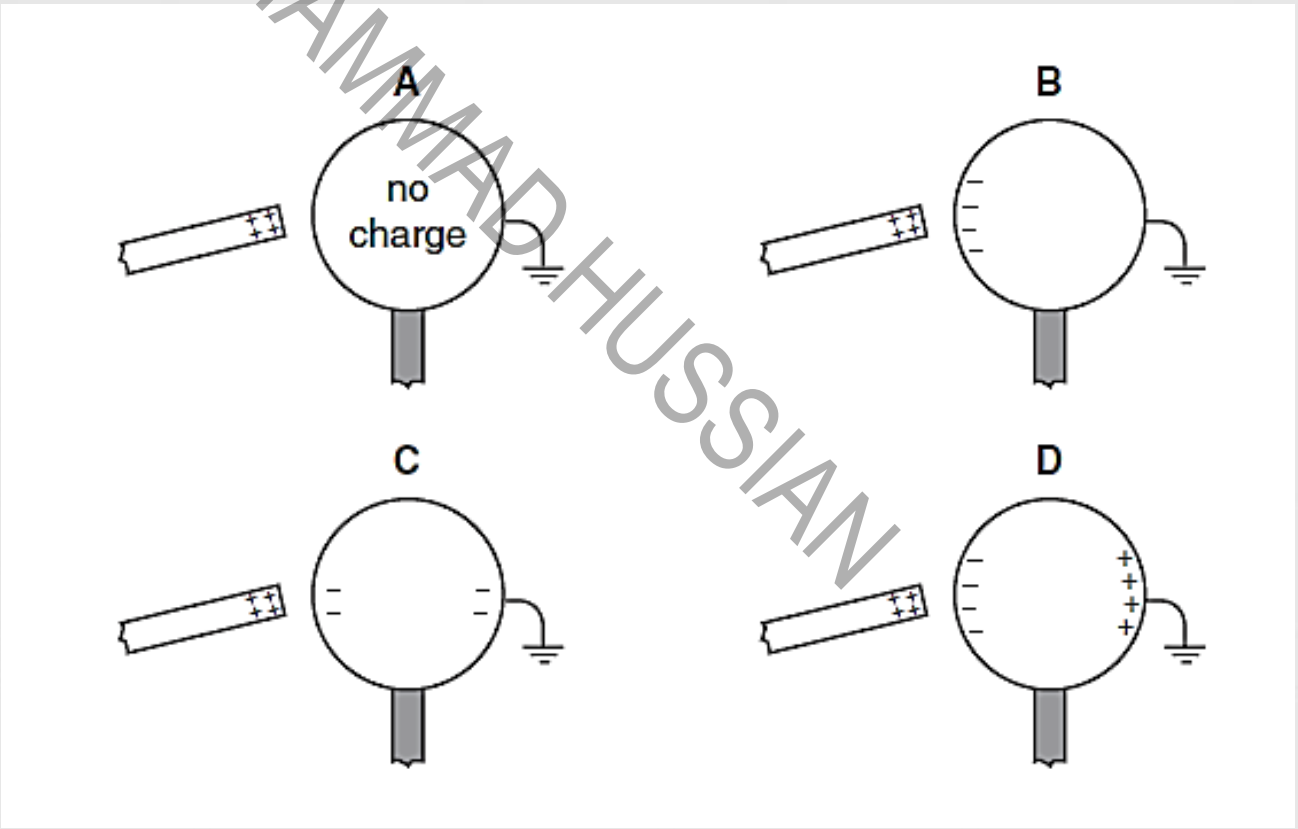


1. Which diagram shows what happens to the spheres?



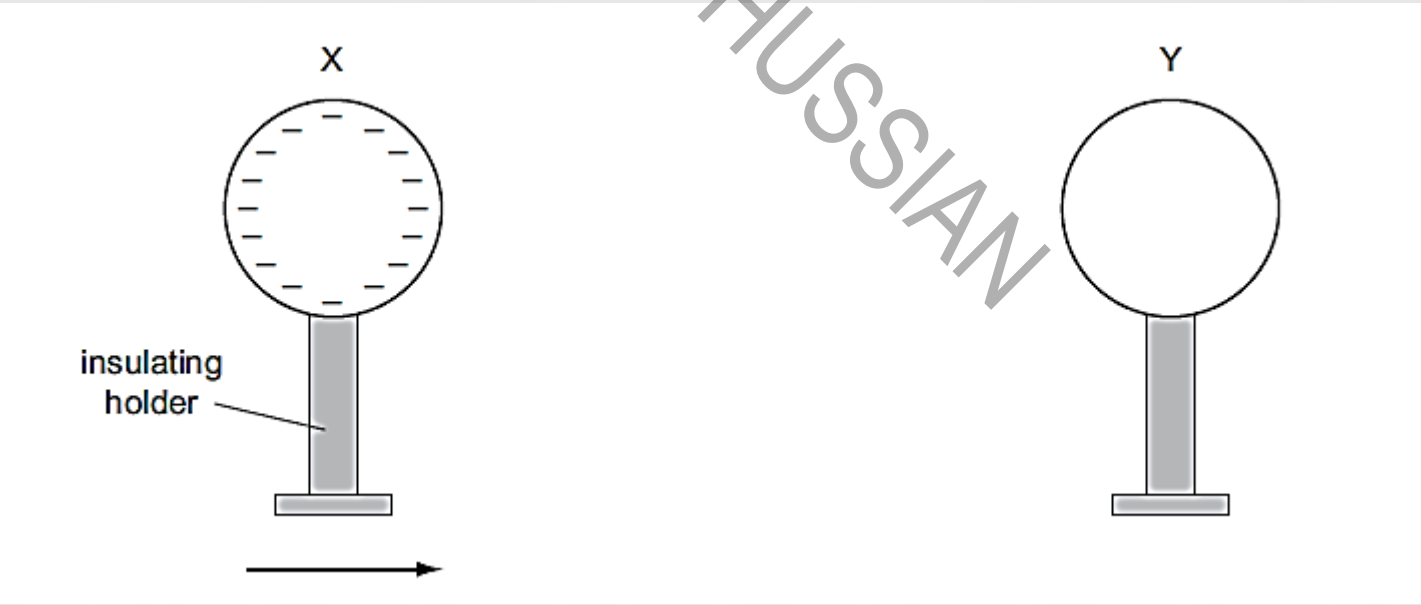
A

15. A metal ball is charged by induction. To do this, a charged rod is held close to one side of the ball and the other side is earthed.
16. Which diagram shows the charge distribution at this stage of the experiment?

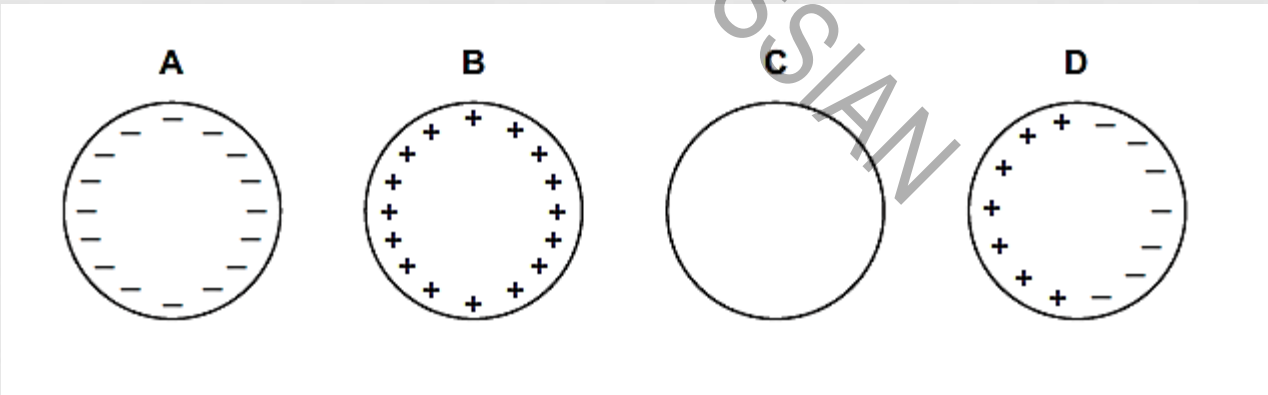


B

16. A negatively-charged sphere X is brought up to an identical uncharged sphere Y. The spheres do not touch.

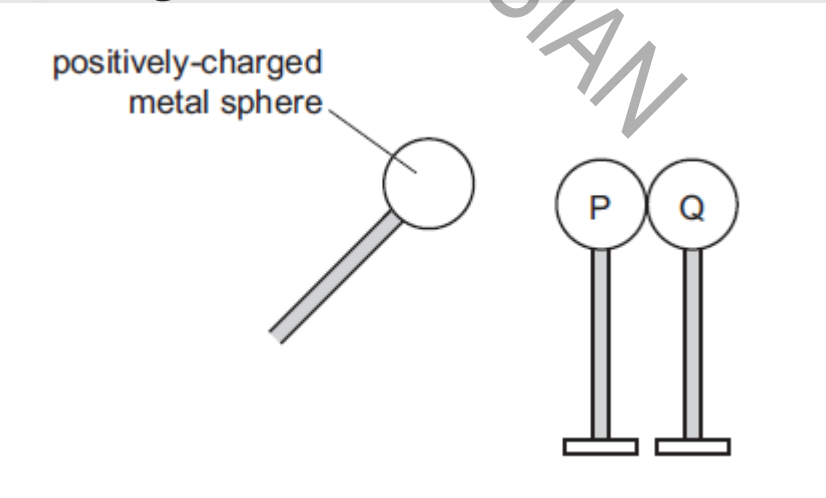


1. Sphere Y is ‘earthed’ by touching it with a finger, which is then removed. Sphere X is then moved away from sphere Y.
2. What is the final charge, if any, on sphere Y?



B

17. Two metal spheres P and Q are mounted on insulating stands and are touching each other. They are uncharged.
18. A positively-charged metal sphere on an insulating handle is brought close to P but does not touch it. This induces charges on P and Q.

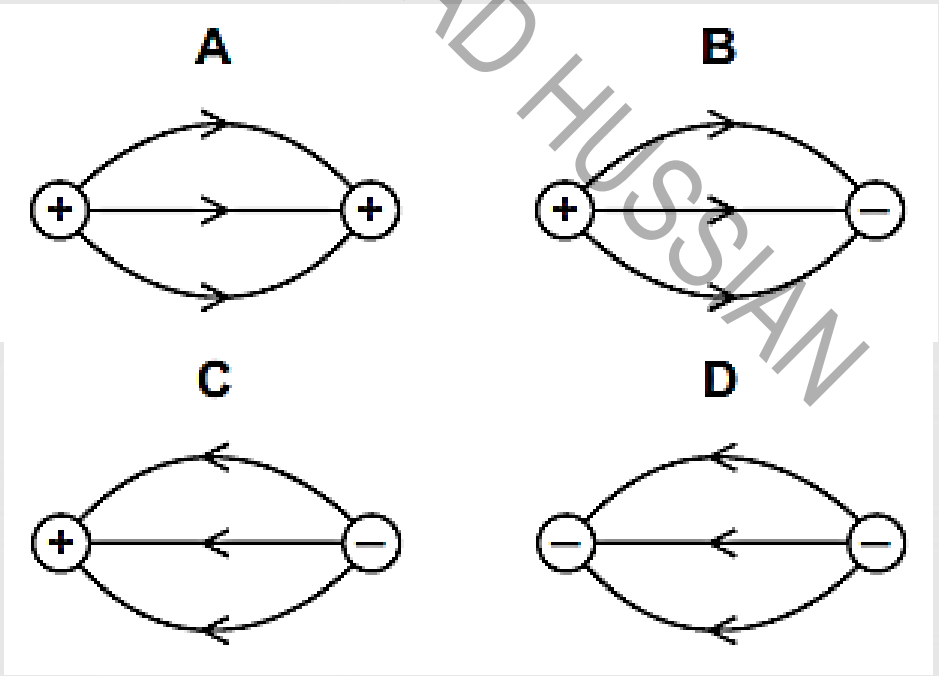


1. The positively-charged metal sphere is held in this position and sphere Q is moved to the right, away from sphere P.
2. What are the signs of the induced charges on P and Q and how do the sizes of these charges compare?

	charge on P	charge on Q	sizes of the charges
A	negative	positive	equal
B	negative	positive	unequal
C	positive	negative	equal
D	positive	negative	unequal

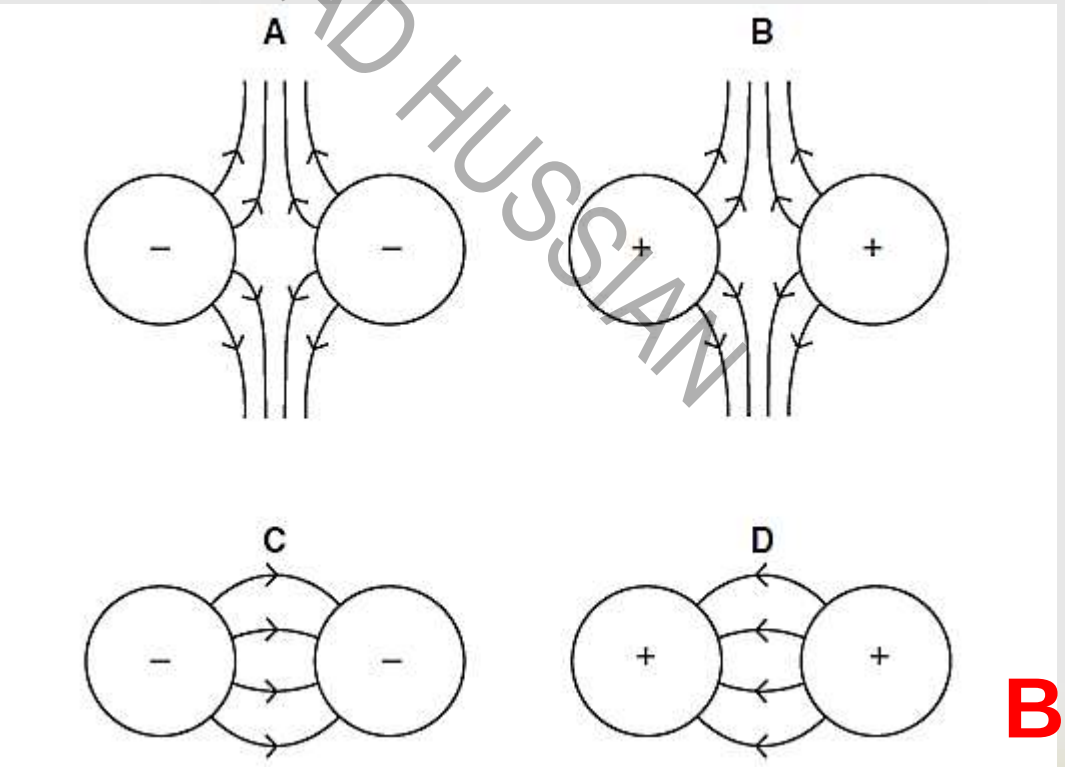
A

18. Which diagram correctly shows the electric field lines between two point charges?



B

19. Which diagram correctly shows the electric field between two charged spheres?

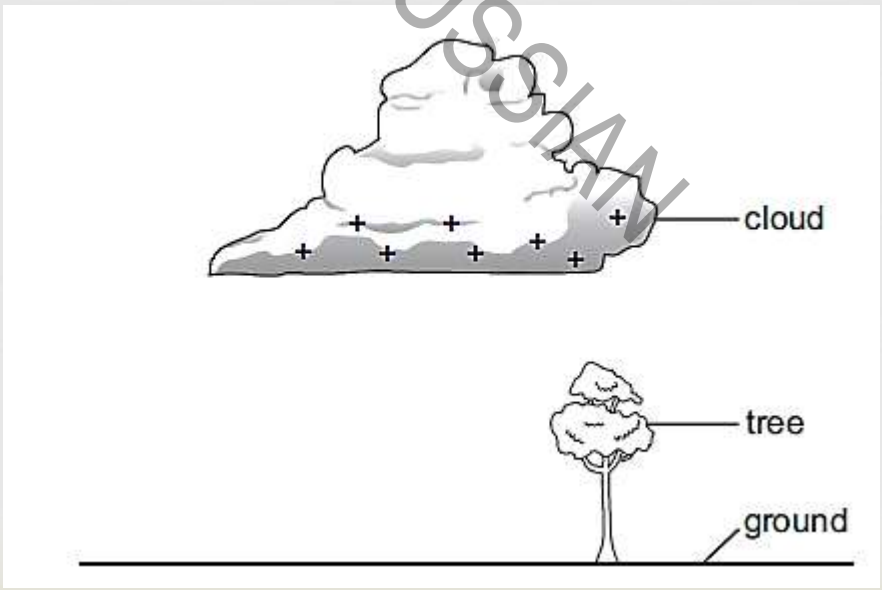


B

20. How many of the following materials conduct electricity?
    - aluminium
    - silver
    - iron
    - plastic

A. 1
B. 2
C. 3
D. 4

21. On a stormy day, a large, positively-charged cloud is above a tree.
22. An electrical charge is induced on the tree as charged particles flow through it.



1. What is the charge induced on the tree and how do the charged particles move?

	charge on tree	movement of charged particles through tree
A	negative	negatively charged particles move down the tree
B	negative	negatively charged particles move up the tree
C	positive	positively charged particles move down the tree
D	positive	positively charged particles move up the tree

B