EXPERIMENTAL MANUAL

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ELECTROSTATICS KIT

Ref. 1080540

ISO 9001:2000 Certified Organisation

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ITEMS INCLUDED

1 Electroscope with Disc Electrode & Hook Electrode – 1 Set
2. Metalized Polystyrene Spheres – 4 Nos.
3. Nylon Thread – 1 Reel
4. Electrophorus – 1 No.
5. Proof Plane – 1 No.
6. Wire Stirrup for Suspending Strips – 1 No.
7. Aluminum Cans, 50×25mm – 2 Nos.
8. Polythene Tiles, 75mm Square – 2 Nos.
9. Polythene Strip, 150x25mm – 1 No.
10. Silk cloth, 250mm Square – 1 No.
11. Woolen cloth, 250mm Square – 1 No.
12. Glass Rod, 10" – 1 No.
13 User Instructions Manual

Other Item Required

1. Laboratory stand with insulating base
2. Paper sheet
3. Colored chalk powder
4. Two rectangular wooden supports

THEORY

All bodies are made up of atoms. Atoms essentially consist of electrons (which are negatively charged), protons (which carry positive charge) and neutrons (which are electrically neutral). In a normal state, the body remains uncharged since the two different types of charges present in the body neutralize each other (being equal in magnitude and opposite in nature).

However, this electrical neutrality of the body changes when transfer of electrons takes place from its surface on being touched or rubbed against other surfaces and electrons from one body move to the other body leaving both the bodies electrically charged. The body that gains electrons acquires negative charge and the one that loses electrons gets positively

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charged. Since, there is no continuous flow of charge, and the charge acquired remains on the surface of the charged body, it is referred to as electrostatic phenomenon.

Different materials have different affinities for gaining or losing charge, for example, acrylic gains negative charge when rubbed against wool while a glass rod acquires positive charge on being rubbed against silk. This method of electrically charging a substance is called electrostatic charging. This effect is more conspicuous when the rubbed substance is a very good insulating material. When the acrylic rod is rubbed with a woolen cloth, electrons are removed from the woolen cloth and are transferred to the rod. The acrylic rod, being a very good insulator, retains these electrons, thus acquiring negative charge. On the other hand, the woolen cloth, which acquires positive charge due to loss of electrons, is not a very good insulator. As a result, the electrons from ground pass on to the cloth through the hands and neutralize this positive charge making it electrically neutral. Acquiring of positive charge by glass rod when rubbed with silk cloth can be explained in a similar way.

The concept of two types of charges acquired by different substances on rubbing (i.e., positive and negative) was first introduced by Benjamin Franklin. He used the following convention for naming the charges.

(a) Charge developed on a glass rod when rubbed with silk is positive.

(b) Charge developed on an ebonite rod when rubbed with flannel is negative.

The choice of convention used by Benjamin Franklin was arbitrary and is still used. It is consistent with the fact that the two opposite kinds of charges tend to cancel each other when brought into contact. If we were to call charge developed on glass rod as negative, and that on ebonite rod as positive, it will not make any difference to the basic concepts of electrostatics.

In fact, Benjamin Franklin was the first person to realize that in any process in which a positive charge is produced, an equal amount of the negative charge must be produced at the same time and vice-versa, i.e., the algebraic sum of these two charges is zero. For example, when ebonite rod is rubbed with flannel, the ebonite rod acquires negative charge and the flannel acquires positive charge equal in magnitude to that of negative charge. This shows the conservation of electric charge.

The list of substances given below is sorted in such a way that if any two substances in the list are rubbed together, the one higher in the list acquires negative charge while the lower one acquires positive charge.

1	Leather coated with amalgam	2	Rubber
3	Ebonite	4	Sulfur
5	Amber	6	Metals
7	Hand	8	Silk
9	Flannel	10	Glass
11	Ivory	12	Fur

* The order given above is approximate since the actual order depends on the specific nature of specimen used.

Following table shows electrical charge acquired by different substance (included in this kit) due to rubbing.

S. No.	Substance to be Rubbed	Rubbing Substance	Nature of Charge on Rubbed substance
1	Ebonite/polypropylene rod	Animal fur/woolen cloth	Negative
2	PVC /acrylic rod	woolen cloth	Negative
3	Glass rod	Silk	Positive
4	Cellulose acetate	woolen cloth	Positive

A rod, when charged electrostatically, attracts different materials, usually smaller in size towards itself, such as pith-balls, styrofoam balls etc. This happens because static charge residing on the surface of charged body induces opposite charge on the other body brought near it and there is electrostatic force of attraction between unlike charges. Similarly, there also exists an electrostatic force of repulsion between like charges.

body is gradually brought closer to the disc terminal of electroscope, more electrons are repelled towards the leaves, further decreasing its divergence and finally the foil leaves collapse completely as the positive charge on the leaves is completely neutralized. On further bringing the charged body near the disc terminal, the foil leaves start diverging again on account of the presence of excess of negative charge (or electrons). Therefore, if the quantum of charge in a charged body is very high, it should be brought near the electroscope terminal gradually from a considerable distance so that the initial divergence is not overlooked. Otherwise, in this type of situation, the observer may notice only the final increase in divergence.

When the charged proof plane is again put well inside the can and touches the can, the foil leaves of the electroscope retain their diverged position. This is because free electrons from the can tend to neutralize the positive charge on the proof plane and result in the can acquiring positive charge. At this stage, the movement of proof plane inside the can does not cause any variation in divergence of the foil leaves. This indicates that the charge on the outer surface of the can (and on that of the foil leaves) remained unchanged (i.e., +Q). On removing the proof plane outside the can, the divergence of leaves still remains the same. Thus, removal of the proof plane from the can inner surface leaves no charge on the inner surface. In other words the contact of the proof plane with the inner surface of the can neutralizes the charge induced on the inner surface of the can. This is further substantiated by the absence of charge on the proof plane. Hence, it can be observed that charge +Q on the proof plane neutralized charge Q induced on the inner surface of the can (i.e., +Q = Q). Therefore, the maximum induced charge is equal to the inducing charge (provided the induced charge completely surrounds the inducing charge).

The absence of charge on the proof plane after it touches the inner surface of the can implies that no charge exists inside a hollow conductor. The presence of positive charge on the outer surface of the can is established by touching the outer surface of the can with the proof plane and testing the nature of charge present on the proof plane using the other electroscope.

PRECAUTIONS

1. Prevent the electroscope kit from moisture and also avoid its contact with materials, which absorb moisture. Water, being conductor of electricity, interferes with the working of the apparatus.
2. All the experiments are to be conducted in dry environment, else the results might be affected.
3. The surfaces of the apparatus must be thoroughly cleaned with a soft dry cotton cloth. Presence of dust particles interferes with the charging/discharging of the apparatus.

Note: When an electrically charged body having very high magnitude of electrical charge is brought near the oppositely charged electroscope from the top towards its metal disc terminal, the divergence of leaves decreases. Suppose the body is negatively charged and electroscope is positively charged. On bringing the body near electroscope, it repels the negative charge (or electrons) on the disc terminal downwards towards the leaves. This partially neutralizes the positive charge on the electroscope leaves and hence, their divergence decreases. As the negatively charged

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Some materials are good conductors of electrons (i.e., they can easily conduct flow of electrons) such as metals, while materials like acrylic and glass are termed as insulators (i.e., they don't permit the free flow of electrons).

Electroscope: It is an important device for the study of electrostatics and is used for determination of presence or absence of electrostatic charge on the bodies. It can also be used for determining the nature of charge on bodies. The main principal behind working of electroscope is the electrostatic force of repulsion between two bodies with similar electrical charge. When an electrically charged body is brought into contact with the electrode or terminal of the electroscope, the terminal also gets charged. This, in turn, charges both the foil leaves with similar charge, since they are in direct contact with the terminal through the conducting rod. The repulsion due to similar electrical charge on both the leaves makes them diverge, irrespective of the nature of charge on the terminal, thus indicating charging of electroscope. When discharged, by bringing an uncharged metal body in contact with the terminal or by touching the terminal with your fingers, there is no charge left on both the leaves and they converge back to the original position. Therefore, diverged position of foil leaves indicates that the electroscope is charged and their fully converged position implies the absence of charge on the electroscope.

Our electroscope consists of a conical flask made of glass (a good insulating material). Electrode assembly is mounted on the mouth of the flask to complete the electroscope. This electrode assembly consists of a rubber stopper with a hole at its center through which an aluminum rod is fixed. The top of the rod is threaded so as to enable it to hold a ball or disc terminal and remains outside the electroscope. The other end of rod has a brass collar attached to it, which is used for suspending the aluminum foil leaves, and is placed inside the electroscope.

Since electric charge is needed to raise a conductor to an electric potential, the position of leaves of electroscope indicates the presence or absence of electric charge. Further, the extent of divergence of the leaves is a measure of the extent of electric charge present on the leaves/electrode assembly.

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Working of an Electroscope: The conducting parts of the electroscope (metal components of electrode assembly of our electroscope) i.e., terminal, metal rod, metal collar and metal foil leaves, can be considered as one single conductor which is well insulated from the glass case of electroscope. The glass case, in turn, insulates the leaves from other secondary external influences making them an isolated conductor. The glass case is generally at zero potential.

Consider the case of a positively charged rod brought near the electroscope terminal as shown in Figure 1. The positive charge on the rod sets up an electric field gradient with the electric field potential decreasing with the increase in distance from the charged rod.

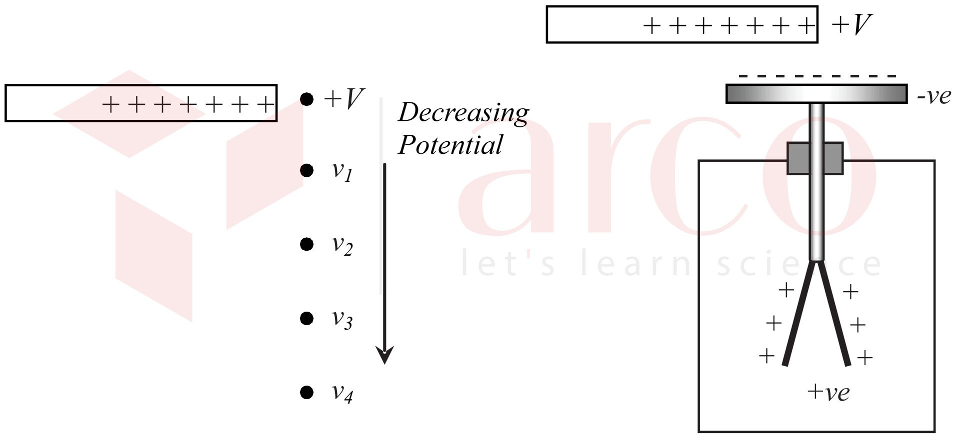

Figure 1: Working of an Electroscope

The terminal end of the electrode assembly is in this electric field, which sets up a potential difference across the two ends of the electrode assembly with the upper end at a higher potential with respect to the lower end. This potential gradient tends to initiate the flow of charges so as to nullify the potential gradient inside the electrode assembly (since no potential difference can exist in a conductor).

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Lower the proof plane again inside the can till the divergence of foil leaves is at its maximum. Touch the proof plane to the inner surface of can. The divergence of foil leaves remain unaffected. Now, even on taking out the proof plane from the can, there is no change in the divergence of electroscope. On testing the presence of the charge on the proof plane at this stage using the other electroscope, the proof plane will be observed to be completely discharged.

Once again, lower the proof plane inside the can and let it touch the inner surface of the can. Test the presence of charge on the proof plane by bringing it into contact with the terminal of the second electroscope. Again, no charge will be observed on the proof plane.

Touch the outer surface of the can with the discharged proof plane. Bring the proof plane into contact with the terminal of the second electroscope and determine the nature of charge present on it. It will be observed that the outer surface of the can has charged the proof plane. The nature of charge on the proof plane will be found to be similar to the charge it had previously before getting discharged i.e., positive charge.

Let '+Q' be the positive charge on the proof plane. As the proof plane approaches the can from the top, it influences the distribution of electrons in the can and the electroscope inductively (i.e., charges electroscope by induction) due to its own electric field. As a result, negative charge is induced on the inner surface of the can and positive charge is induced on the outer surface of the can and the terminal/foil leaves of electroscope. Hence, the foil leaves of the electroscope diverge. As the proof plane is lowered further into the can, its inductive influence on the can increases, since its electric field is more and more surrounded by the can. This increases the electric charges induced on the inner and outer surface of the can and also the divergence of the foil leaves. When the proof plane is well inside the can, almost all of its inductive action is confined to the can only with its effect outside the can becoming negligible. At this stage, maximum charge has been induced on the can and the electroscope. Thus, further lowering of the proof plane does not increase the divergence of the foil leaves of the electroscope. Let the electric charge induced on the inner surface of the can at this stage be Q (being negative charge) and that on the outer surface of the can and on the electrode assembly be +Q.
On withdrawing the proof plane outside the can without touching the can, there is no longer any effect of charged proof plane on the can and the induced positive and negative charges neutralize each other. Therefore, the foil leaves of the electroscope converge back to their original position. Since after the induction of charge on the can due to the charged proof plane, the can regains its electrical neutrality, it is implied that the magnitude of positive induced charge is always equal to the negative induced charge (i.e., Q = +Q).

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disc terminal of other electroscope gets positively charged due to the second electroscope being at a lower potential and the electrons moving towards the first electroscope. This is due to the rearrangement of electrons in both the electrodes (as they are in physical contact with each other through the conducting medium), so as to bring both the electrodes to uniform electric potential with respect to the positively charged glass rod. As a result, the negative charge moves from terminal of electroscope farther from the glass rod to the one nearer glass rod. On separation, the electroscope which was nearer to the glass rod, retains the negative charge, while the other one retains positive charge. At this stage, when both are touched with glass rod again, the foil leaves of the electroscope having positive charge diverge more, while the foil leaves of the other electroscope converge. If the disc terminal of both the charged electroscopes are brought into contact with each other, again redistribution of electrons take place in order to establish the equilibrium of electrical charge and foil leaves of both electroscopes converge back (since the system involving both the electroscopes, on the whole, is electrically neutral and has been charged by induction).

EXPERIMENT 11: FARADAY'S PAIL EXPERIMENT.

ITEMS REQUIRED

1 Electroscopes with disc terminal – 2 Nos.
2 Aluminum Can
3 Polythene Strip / Glass Rod
4 Woolen / Silk Cloth
5 Proof Plane

PROCEDURE: This experiment also requires two electroscopes. Position an aluminium can (also called Faraday's pail) on top of the terminal of a completely discharged electroscope.

Charge the proof plane by bringing it in contact with a charged glass rod. It will acquire positive charge. Bring this charged proof plane near the electroscope and lower it slowly into the aluminum can in such a way that it does not come into contact with the inner surface of the can. As soon as the proof plane approaches the can, foil leaves of the electroscope will diverge. The divergence of foil leaves will increase as the proof plane is lowered more and more into the can until it is well within the can. On further lowering the proof plane beyond a certain point, there is no increase in divergence of the foil leaves. On taking out the proof plane, the foil leaves converge back to their original position.

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Positive charge always flows from higher potential to lower potential and vice versa. The conductor is at a positive potential due to the electric field of the positively charged rod. Thus, redistribution of charges takes place with the negatively charged free electrons in the conductor of electroscope flowing from its lower portion to higher portion till the conductor has no potential difference across its ends. This results in the top of conductor getting excess of electrons and the bottom having shortage of electrons. As a result, the foil leaves get electrically charged and deflect away from each other.

On removing the positively charged object, electric field due to it no longer exists. Consequently, the equal and opposite charges on the two ends of conductor give rise to potential difference across its two ends. This again tends to initiate the flow of charges so as to nullify this potential gradient. Thus, the charges redistribute themselves with the flow of electrons (from top) neutralizing the excess of positive charge (at the bottom) resulting in the absence of any charge in the foil leaves. Hence, the leaves fall back to their original position.

EXPERIMENT 1: ELECTROSTATICALLY CHARGING THE OBJECT BY RUBBING.

ITEMS REQUIRED

1. Polythene Strip 2 Woolen cloth
3 Metalized Spheres

(Other combination of glass rods / silk cloth can also be used for this experiment).

PROCEDURE: Charge the polythene strip by rubbing it against the woolen cloth. Put some metalized balls on a table and bring the strip close to the metalized balls. You will observe that the strip attracts metalized balls towards it.

On being rubbed against the woolen cloth, the polythene strip acquires electrical charge, which induces opposite charge in the metalized spheres. Thus, the balls get attracted toward the polythene strip. Similar results will also be observed by repeating the experiment with small bits of papers instead of metalized balls. Hence, it can be concluded that a body acquires static charge due to friction, when rubbed against another body.

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EXPERIMENT 2: TO STUDY THE INFLUENCE OF CHARGED BODIES HAVING LIKE / UNLIKE CHARGES ON EACH OTHER.

ITEMS REQUIRED

1	Polythene Strip	2	Glass rod
3	Nylon thread	4	Silk cloth
5	Woolen cloth	6	Laboratory stand

PROCEDURE: Take a piece of thread and tie it around the center of the polythene strip. Charge the strip by rubbing it against the woolen cloth. Suspend the strip on a laboratory stand through the thread tied to it. Now, charge the glass rod by rubbing it against the silk cloth. Bring the charged glass rod close to the suspended strip. The strip will get attracted to the glass rod. It implies that both the rods have opposite charge. Usually, on rubbing, glass rod acquires positive charge whereas the polythene strip acquires negative charge, and start attracting each other.

In a similar way, it can also be demonstrated that like charges repel each other. This can be done by using two rods / strips of similar materials (by borrowing the second one from similar kit) or by using polythene tile with the strip, that acquire similar charge on rubbing. In this case, the suspended strip / rod will move away from the other, when brought near it. This shows that the like charges repel each other, whereas unlike charges attract each other.

EXPERIMENT 3: CHARGING THE METALIZED BALL BY CONDUCTION.

ITEMS REQUIRED

1	Polythene Strip	2	Glass rod
3	Nylon thread	4	Silk cloth
5	Woolen cloth	6	Laboratory stand

PROCEDURE: Suspend the metalized ball from the laboratory stand using nylon thread. Charge a polypropylene strip by rubbing it against the woolen cloth and bring it near the metalized ball. The ball will be attracted towards the rod. On coming in contact with the rod, the ball moves away. On bringing uncharged glass rod near the ball from the side opposite to that of polypropylene strip, the ball will be observed to move towards glass rod. On touching this second rod, again the ball will move away from the glass rod towards the polypropylene strip. Thus, the ball will continuously move back and forth between the two rods till equilibrium of charge is established among the three objects.

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The nature of charge of an object can be tested better using three electroscopes. Charge one electroscope with positive charge, one with negative charge and keep the third one neutral. Charge the neutral electroscope from the object under observation either by directly touching the terminal of electroscope with the charged object or through the charge transfer ball. If the foil leaves deflect away, it indicates the presence of charge on the object, and if the foil leaves are not deflected, the object is not charged. In case the object is charged, transfer its charge to the positive electroscope. In case the deflection of foil leaves increase, it indicates the object is positively charged, since it is attracting electrons from the foil leaves, thus making them more positive. If the deflection of the foil leaves decrease, the object is negatively charged, since it is repelling electrons into the foil leaves, thus partially neutralizing the positive charge. This can further be verified by transferring the charge from the charged object to the negatively charged electroscope.

EXPERIMENT 10: STUDY OF CHARGING BY INDUCTION USING TWO ELECTROSCOPES.

ITEMS REQUIRED

1	Electroscopes – 2	2	Glass Rod
3	Silk Cloth		

PROCEDURE: This experiment requires two electroscopes. Place both the electroscopes in such a way that their terminals are touching each other. If both the terminals don't touch each other, connect them using a conducting wire. When a charged glass rod is brought near one of the electroscopes, foil leaves of both the electroscopes will deflect, indicating the presence of charge in them. Remove the glass rod after moving both the electroscopes away from each other. The foil leaves of both the electroscopes still do not converge back, thus indicating their charged state. Now, touch the disc terminal of each electroscope with the charged glass rod rubbed with silk. You will observe that the foil leaves of one of the electroscope diverge more, whereas in the other, foil leaves converge back. This implies the presence of opposite charges in both the electroscopes. If, instead of touching the disc terminals of both the charged electroscopes with glass rod, their disc terminals are brought in contact with each other, foil leaves of both the electroscopes will be observed to fall back.

Here, the close proximity of positive charge of the glass rod to one of the electroscopes results in the induction of the negative charge on the disc terminal of this electroscope which is nearer to the glass rod whereas the

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Similar results will be observed with a negatively charged rod, for example, polythene strip rubbed with woolen cloth.

This method of charging of electroscope is referred to as charging by induction with a known type of electric charge. Here, it can be observed that the charge induced in the foil leaves of the electroscope is always opposite to the electrical charge on the rod inducing it, i.e., if positive charge is to be induced on a body, negatively charged body should be brought near it and vice-versa.

EXPERIMENT 9: DETERMINATION OF NATURE OF CHARGE ON A BODY.

ITEMS REQUIRED

1 Electroscope 2 Glass Rod
3 Polythene Strip 4 Woolen Cloth
5 Silk Cloth 6 Proof Plane

PROCEDURE: The nature of charge on a charged body can be determined with the help of an electroscope. For this, charge a fully discharged electroscope with the unknown charge either by directly bringing the unknown charged body in contact with the disc terminal of electroscope or by using the proof plane. If the charged body has high magnitude of electrical charge or its size is big, it is advisable to use the proof plane. In this case, bring the proof plane in contact with the charged body by holding it from the insulated handle. This charges the proof plane with the similar charge by conduction. When the terminal of discharged electroscope is touched by the proof plane, electroscope gets charged by conduction with the similar kind of charge, whose nature is to be determined. The charging of the electroscope is indicated by the diverged position of its foil leaves.

Charge a glass rod by rubbing it against silk cloth. It will acquire a positive charge. Bring the positively charged rod in contact with the disc terminal of the charged electroscope. If the foil leaves deflect more, it is implied that a similar charge has been acquired by the electroscope, with which it is already charged. Hence, it can be concluded that the body under observation is positively charged. Conversely, if the foil leaves converge back, it indicates that the charge residing on the leaves of electroscope has been neutralized, partially or completely, with the opposite charge. Thus, the body under observation is negatively charged.

This experiment can also be performed using the polythene strip rubbed against the woolen cloth, which acquires negative charge and can be compared to the unknown charge in a similar way.

The negatively charged polypropylene strip attracts the metal ball due to induction of opposite charge on the ball. In this case, redistribution of charge takes place in the ball in such a way that the electrons move away from the side of the ball near the charged rod making that side positively charged, whereas, the opposite side of the ball gets negatively charged. But when the ball comes in contact with the charged strip, electrons are attracted from the rod by the positively charged side of the ball so as to neutralize it. This makes the ball negatively charged due to the transfer of excess electrons and thus, it is repelled by the strip and moves away. On bringing the uncharged glass rod near it, the ball gets attracted to the rod due to induction of opposite charge on the rod. When it comes in contact with the uncharged rod, it loses the electrons to the rod and is repelled back. In the process it becomes discharged and again gets attracted towards the charged strip. Same process is repeated and therefore, similar behavior of the ball is observed again and again.

EXPERIMENT 4: EFFECT OF PAPER FIXED TO ACRYLIC PLATE ON THE CHARGING OF THE ACRYLIC PLATE.

ITEMS REQUIRED

1 Polythene Tile
2 Woolen cloth
3 Paper sheets
4 Two rectangular wooden supports
5 Fine powder (such as finely ground pepper etc.)
6 Adhesive Tape

PROCEDURE: Cut a small piece of paper into a rectangular 'D' shape and fix it in the center of the polythene tile using adhesive tape. Take another sheet of paper and sprinkle the powder uniformly over its whole surface. At each of the two ends of this paper sheet, place a rectangular wooden support (or any other insulated supports such as books, about 2-3cm high). On these supports, position the polythene tile so that the taped paper faces down towards the powder placed on paper sheet. Now, rub the woolen cloth against the top surface of the polythene tile to charge it. The plate gets charged except for the area covered by the paper. The powder will be attracted towards the whole area of the polythene tile, but it will fall off from everywhere except where the paper is. The powder is attracted to the whole polythene tile since the plate is negatively charged. But the powder falls off from all areas due to the powder getting negatively charged by conduction of electrons from the polythene tile. However, this does not happen in the area where the paper is fixed, since there is no conduction of electrons from the plate (due to the absence of any charge in this area).

The same principle is observed in every-day life in a photocopying machine.

EXPERIMENT 5: CHARGING THE ELECTROPHORUS.

ITEMS REQUIRED

1 Electrophorus
2 Woolen cloth
3 Polythene Tile

PROCEDURE: An electrophorus is a simple device designed by Volta in 1775 for obtaining a large number of charges from a single charge. It operates on the principle of electrostatic induction. The electrophorus consists of a circular metal plate with an insulating handle attached to it.

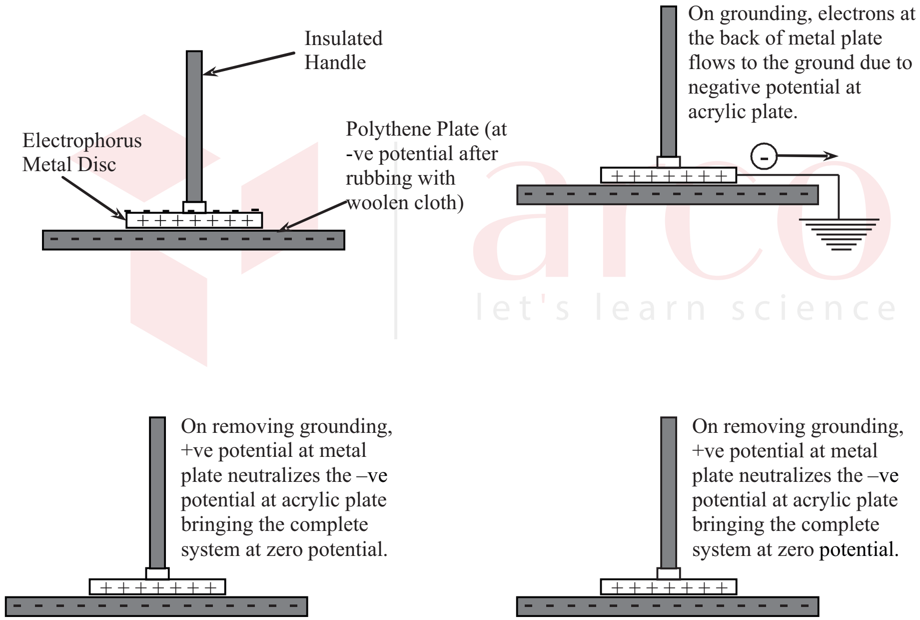


Figure 2: Charging the Electrophorus

When a positively charged glass rod is brought sufficiently close to the terminal of electroscope, positive charge on the glass rod sets up an electric field gradient with electric field potential decreasing with the increase in distance from the glass rod (as discussed in the working of electroscope). As a result, the terminal (upper portion of the electrode) is at higher potential of this electric field than the foil leaves (lower portion of the electrode). This sets up a potential difference between the upper and lower end of the electrode assembly. The electrode, being of metal, has a large number of loose electrons. Redistribution of these loose electrons takes place so as to nullify the potential gradient inside the electrode assembly (since no potential difference can exist in a conductor) and bring it to a uniform potential. Thus, the electrons in the conductor of the electroscope flow from its lower portion towards the disc terminal till the complete conductor achieves a uniform potential. This leads to the electroscope terminal getting excess of electrons and the lower end having shortage of electrons. As a result, the foil leaves get electrically charged with positive charge and deflect away from each other {as shown in Figure 4 (a)}. Since this is simply a case of rearrangement of electrons, the conductor, on the whole, remains electrically neutral. When glass rod is removed away from the disc terminal, again redistribution of electrons takes place to nullify the effect of potential difference due to polarization of the upper and lower end of the electrode assembly and results in the neutralization of electrical polarities formed previously making the foil leaves converge back to their original position.

Again, when the charged glass rod is brought near the terminal of the electroscope, the electric field due to positively charged glass rod raises the electric potential near electroscope terminal as compared to that of ground. Thus, when the disc terminal is touched by the fingers or is connected to the ground momentarily {as shown in Figure 4 (b)} with the glass rod still near it, the electrons flow from the ground to the electroscope terminal and to the foil leaves due to their attraction by the positive charge at the lower end of conductor. These electrons neutralize the effect of positive charge on the foil leaves, making them fall back to their original position. On removing the ground connection, the electrons transferred from ground to the electrode are retained by the electrode. When the glass rod is moved away, the potential at the electroscope terminal becomes less than that at the lower end of the conductor. This again results in the rearrangement of electrons with the electrons moving from terminal towards foil leaves (this can also be explained as a result of electrostatic force of repulsion between excess electrons at the disc terminal that makes electrons move away from the disc terminal). Consequently, the foil leaves get negatively charged and deflect. In this case, the charging of electroscope is permanent.

EXPERIMENT 8: CHARGING ELECTROSCOPE BY INDUCTION.

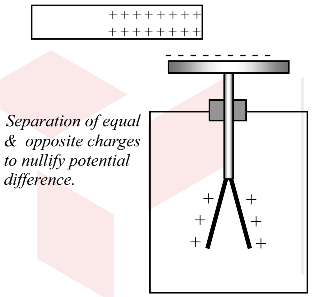
ITEMS REQUIRED:

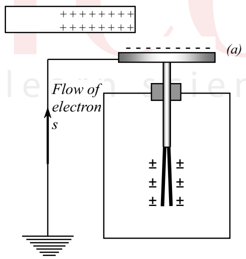
1 Electroscope 2 Glass Rod

3 Silk Cloth

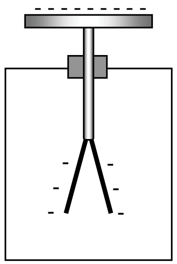
PROCEDURE: Completely discharge the electroscope and bring a positively charged glass rod (rubbed with silk) just near the terminal of the electroscope. You will observed that the foil leaves deflect. As soon as the glass rod is moved away from the terminal, the foil leaves fall back to their original position. Again, bring the charged rod near the disc terminal and with the foil leaves in diverged position, touch the disc terminal with fingers, or ground the terminal using a conducting wire momentarily. The foil leaves will converge back. After removing the finger or ground connection, move the charged glass rod away from disc terminal. It will be observed that the foil leaves again assume the diverged position.

(a) Separation of equal & opposite charges to nullify potential difference.





(a) When grounded, higher potential at the terminal due to charged rod makes the electron flow from ground to the terminal an d to the foil leaves, nullifying the effect of positive charge on foil leaves.



(a) On removing ground connection and then moving the charged rod away from the terminal, the charge acquired by the conductor remains on conductor, thus making it permanently charged with the nature of charge opposite to that on the rod.

For charging the electrophorus, place the polythene tile on an insulated surface and rub it gently with the woolen cloth. Since electrons get removed from the woolen cloth and are transferred to the polythene tile, this makes the surface of polythene tile acquire negative potential. Place the metal disc of electrophorus on the polythene tile. Although, the metal disc is in contact with the charged polythene tile, the charge from polythene tile does not get transferred to the metal disc. This is due to the large number of irregularities on the surface of both polythene tile and metal disc so that the contact between these two surfaces is at very few points and there is air film separation (insulation) between the two surfaces for the most part.

Polythene tile itself being good insulator, charge cannot flow across its surface to the metal disc. The negative charge on the surface of polythene tile repels electrons in the metal disc causing a separation (or redistribution) of charges across the thickness of metal disc such that the bottom portion of metal disc (in contact with the polythene tile) acquires positive charge, while its opposite surface acquires negative charge. In this way the electrophorus gets charged by the process of induction. On grounding (using finger, for example) the top surface of metal disc having negative charge, the negative potential of polythene tile repels the electrons to ground through the ground connection so that the net potential due to polythene tile and metal disc is zero (i.e., the positive charge on the metal disc balance the negative charge on polythene tile). On removing the ground connection, this zero potential is retained. When the metal disc is lifted by holding it from the insulated handle, it will have positive charge due to redistribution of electrons (since the metal disc has lost electrons due to negative potential of polythene tile). In other words, as the positively charged metal disc is moved away from the negative potential of the polythene tile, some work must be done against the force of attraction. If 'Q' is the charge on the polythene tile and 'V' is the potential difference due to this charge, work done is QV (in Joules) and this gain in energy is responsible for the metal disc becoming charged.

On discharging the metal disc, it can be charged again with the positive charge following the procedure as discussed above, so long as the polythene tile retains its negative charge.

The fact that opposite charges reside on polythene tile and electrophorus disc, can be established using an electroscope.

Bring the charged electrophorus to the electroscope and touch the terminal of electroscope with disc of electrophorus. The leaves of the electroscope will diverge which indicates the transfer of electrical charge from electrophorus disc to electroscope. Since, both the leaves acquire similar charge, they repel. Remove the electrophorus disc and touch the electroscope terminal with the polythene tile. This will make the leaves of electroscope converge back to their original position due to redistribution of charge for electrical equilibrium between the two showing that the polythene tile has opposite charge with respect to the electrophorus.

EXPERIMENT 6: TO EMPHASIZE THAT THE ELECTROSCOPE OPERATES BY POTENTIAL DIFFERENCE RATHER THAN ELECTRIC CHARGE.

ITEMS REQUIRED

1 Electroscope 2 Polythene Strip

3 Woolen cloth 4 Glass Rod

5 Silk Cloth

PROCEDURE: Charge the Polythene Strip negatively by rubbing it against the woolen cloth. Bring the charged Polythene Strip near the terminal of the electroscope. This will result in the deflection of the foil leaves of the electroscope due to induction. On removing the charged rod away from the terminal, the leaves will fall back to their original position.

Now charge the glass rod positively by rubbing it against silk cloth and repeat the above procedure. You will observe the similar behavior of electroscope. Thus, from these two observations, it can be seen that the foil leaves get deflected by both positive and negative charge. Hence, the deflection must be due to the potential difference set up by the charged rods rather than the nature of charge. More is the charge, more will be the potential difference due to it and more deflection will be produced in the foil leaves of the electroscope.

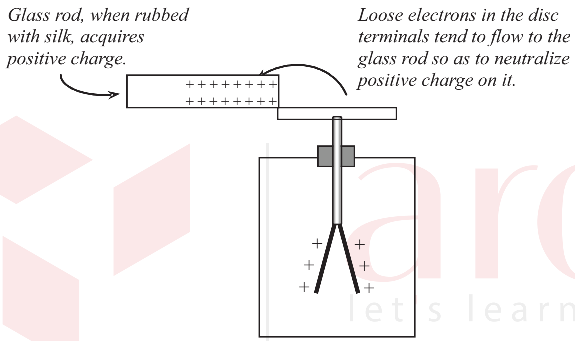
EXPERIMENT 7: CHARGING ELECTROSCOPE BY CONDUCTION.

ITEMS REQUIRED

1 Electroscope 2 Glass Rod

3 Silk Cloth

PROCEDURE: Make sure that the electroscope is in completely discharged position (i.e., its foil leaves are fully converged). If not, discharge it by touching the terminal with your fingers or an uncharged metallic object. Rub the glass rod with the silk cloth, which will acquire positive charge. Touch the terminal of the electroscope with the rubbed part of the glass rod. You will observe that the electroscope gets charged with their leaves immediately diverging. If the glass rod is now removed, foil leaves still remain diverged. In fact, if the glass rod is removed slightly after touching to the disc terminal and then its charge is removed by touching the rubbed portion with fingers, the electroscope leaves still remain diverged. This indicates that once the electroscope has been charged by conduction, it is not influenced by the discharging of rod even if the rod is near it. But if the electroscope terminal is touched with the fingers in its charged state, the foil leaves collapse back, indicating the discharging of the electroscope.



When the electroscope terminal is touched with a positively charged rod, a channel opens for the flow of electrons from the electrode to the charged rod, making the electrode positively charged. This is because the metallic terminal has loose electrons, which gets attracted towards the positively charged body, which has a deficiency of electrons. This in turn makes the foil leaves of electroscope positively charged and the leaves deflect away due to electrostatic force of repulsion between them. Since in this case, actual transference of electrons takes place, the charge on electroscope is permanent in nature. The neutralizing of charge on glass rod after it is removed slightly away from the electroscope terminal does not influence the divergence of foil leaves since neither there is any flow of charge from electrode nor any redistribution of charge. When electroscope terminal is touched with the fingers after the removal of glass rod, electroscope is grounded due to the flow of electrons from the hand to neutralize the positive charge on electroscope, thus discharging the electroscope and the leaves collapse back. This type of charging of a body is referred to as charging by conduction

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