615-3075 (10-093) Electroscopes Kit

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Introduction:

This kit helps you experiment with the Electroscope, an apparatus for detecting electrostatic charges and identifying their kind (+ or -). It is useful for all experiments where you need to detect charges. It is an excellent companion for two other basic kits on Electrostatics:

615-3090 (Electrostatic Charge Kit)
615-3095 (Faraday Cage Kit).

Other accessories good for experiments in electrostatics manufactured by **Science First®** include: Van de Graaf generators, electroscopes, proof planes, 615-3085 Electrostatic Kit
and 615-3015 Friction Rod Kit.

Product Description:

The main components of the electroscope are its vanes, a pair of thin metal foil leaves sensitive to electrostatic charges. They are connected together at one end so they spread apart (repel each other) or collapse (come close together). The vanes are enclosed in a 250 ml flask and are hung on four (4) brass hooks by means of holes at one end. The hanger connects to a short metal rod which passes through (and ends outside of) an insulating stopper that closes the mouth of the flask. This permits the metal ball terminal to be placed on the flask stopper, so it is in direct contact with the rod end; or the metal disc terminal to be screwed on to the rod end. This provides a direct conductive channel to any electric charge landing on the terminal, all the way to the foil leaves.

[When the leaves are charged, they spread apart because of similar charges on both leaves. In their neutral state, they remain collapsed.]

Use and Care of Equipment:

Maintain the materials in this kit between use by taking the following precautions so your experiments can yield maximum results:

Protect insulating materials from salt spray, chemical flames and perspiration. They coat them with a film of moisture which may conduct away electric charges, thereby affecting your experiments. You can, however, remove any moisture film buildup with a rinse of distilled water.

Your experiments are BEST performed in a dry room, for the same reason. Avoid handling the material with moist hands.

At high humidities (over 80%), lint strands may cause short circuits or act as discharge points. If you are using an electrophorus with this kit, be aware that damp lint diminishes the maximum potential of metal surfaces and makes electrophorus less effective.

Watch for any radiation, open flames or other media that might ionize the nearby air. These will slowly discharge the bodies you have charged and are testing with the electroscope.

Experiments and Activities

Experiment 1:
Charge an Electroscope by Induction

An electroscope detects the presence of an electrostatic charge by being "charged" by it. Try charging the electroscope, first with a positive charge and then with a negative charge.

1. Fit one of the electroscopes with a ball terminal assembly.
2. Charge a glass rod positively by rubbing it with silk and bring the charged (rubbed) end close to, but not in contact with, the ball terminal of the electroscope.
3. Observe the leaves of the electroscope diverge (go apart).
4. Remove the charged rod away from the electroscope terminal and observe the electroscope leaves collapse.
5. Repeat the entire procedure above, and observe the leaves repeat their behavior, diverging and collapsing just the way they did before.
6. Repeat the entire procedure, using an uncharged glass (or other) rod. The leaves do not diverge.
7. Instead of the positively charged (glass) rod, use a negatively charged rod (rub acrylic with wool or flannel) and repeat. Observe that the leaves behave exactly as they did with a positively charged rod.

Conclusion:

Any charged body (either positive or negative) brought close to, even though not in contact with, an electroscope terminal, makes the leaves diverge. They collapse when the charged body is taken away.

8. Try a variation. Bring a positively

charge rod close to the electroscope terminal and touch the terminal with your finger. Now remove the rod. Notice that the diverged leaves remain diverged, instead of collapsing as they did in step 4 and 5.

Conclusion:

In this experiment, the leaves not only acquire the charge, they also retain it. The electroscope is "charged."

Discussion:

1. This experiment is a case of charging the electroscope by *"electrostatic induction"*, where a charged body (the rod) *"induces"* an opposite charge in an uncharged body (the electroscope terminal and the leaves, which are really an extension of the terminal, being connected to it through electrically conductive parts). This happens due to the reorientation of molecules in the uncharged body so their electrons will be closest to the positive end of the charged body. In other words, more electrons are drawn toward the terminal, causing the leaves to have less of them; or, electrons are driven to the leaves from the terminal, as the case may be. The leaves thus acquire the same charge as the rod, and the terminal the opposite charge, by induction.
2. Why the divergence of leaves? Both leaves acquire a similar charge by induction, positive or negative, with the result that they repel each other.3. What makes the leaves collapse? In induction, there is no contact between bodies, no actual transfer of electrons, only a temporary rearrangement of them by the reorienting molecules. Once the "charge inducing" rod is removed, the molecules return to their normal state, and the leaves no longer carry the charge, and they collapse (no need to repel each other).
4. Why do the leaves retain the acquired charge in the end of the experiment, but not earlier? It is because you have "grounded" the induced charge on the terminal (removed excess electrons from it) by touching it with your finger. The leaves continue with the positive charge they acquired.
5. You can use an electroscope to verify the presence or absence of an electrostatic charge on a body. A diverging electroscope indicates the presence of a charge on the rod; and a non-diverging electroscope (with collapsed leaves) means the rod had no charge on it.
6. Induction is actually a consequence of the forces of attraction and repulsion between charges in an electrostatic "field".

Experiment 2:
Charge an Electroscope by Contact

You can charge an electroscope by ***conduction*** *rather than by* ***induction*** *(unlike the previous experiment) by having the charged body in direct contact with the terminal. Use it as follows.*

1. As in the previous experiment, set up the electroscope with the ball terminal assembly (or, for variety, the disc terminal assembly).
2. Bring a positively charged rod close to the terminal and see the leaves diverge.
3. Now actually touch the terminal with the charged end of rod and note that the leaves remain diverged.
4. Remove the rod and observe that the leaves still remain diverged.
5. Repeat, this time using a negatively charged rod instead of positive, making sure that you discharge the electroscope first. Note that the leaves behave the same way as before, and remain diverged.

Conclusion:

The electroscope gets charged when its terminal comes into contact with a (positively or negatively) charged body.

Discussion:

1. This is a case of *charging by conduction.* When the charged rod is brought close to the terminal, it induces an opposite charge in the terminal by induction, while the leaves acquire the same charge as the rod. But then when the rod touches the terminal it establishes a continuous conducting channel for the flow of the electrons into it, so the electroscope assembly now stays with a net negative charge.
2. Whereas induction is a case of mere reorientation of molecules (that is to say, a temporary repositioning of electrons) within the uncharged body, during conduction there is actual transfer of electrons to fill in the deficiency.
3. Compare the act of "touching" in this experiment to the action of the finger previously.

Experiment 3:
Use an Electrophorus or a Proof Plane to charge an Electroscope

Note: for this experiment, use the electrophorus from **10-092** *Electrostatic Charge kit, obtain one from Science First® or a science education dealer, or make your own.*

1. Impart a positive charge to an electrophorus by placing it above a negatively charged (acrylic rubbed with acetate cloth) plate; draining off excess electrons from its top by grounding; and lifting it off the plate along with the net positive charge it has acquired.
2. Now perform the Experiments I and 2 and charge the Electroscope using the Electrophorus in place of the (positively) charged rod.
3. Alternatively, you can charge the electroscope by transferring charges a bit at a time from the electrophorus, using a proof plane. This method of charging an electroscope is convenient, as you will see later,

when you have to repeated charge it for identification of an unknown charge, that is, to find out which kind of charge (+ or -) a body is carrying.

Note: our companion kit 10-092 carries a proof plane. A separate proof plane is also available directly from us.

Experiment 4:
Determine an unknown charge with the help of on a body an electroscope

1. Set up the electroscope, either with a ball terminal or a disc terminal.
2. Charge it positively by any of the following methods:
a. Hold a negatively charged rod (acrylic rubbed with acetate cloth) close to the terminal. Touch the terminal with your finger. This will repel and drain off electrons from the electroscope into your body, and leave it with a net positive charge.
b. You can directly transfer charges from a reservoir of positive charges, such as a charged electrophorus, on to the electroscope terminal and charge kit by conduction.
3. Since you know what kind of charge the electroscope has (positive charge in this case), you can easily identify the sign of an unknown charge brought to its terminal.
a. Bring the charged body in close to the terminal. Observe whether the vanes (which are already diverged) will diverge even more or just collapsed.
b. In the first case you can conclude that the body is positively charged, whereas in the second case, it is a negatively charged body.

Discussion:

1. The positively charged vanes of the electroscope diverge even more by any positive charge(s) placed at its terminal, because it causes electrons to be attracted and driven up into the terminal from the leaves.
2. On the other hand, any negative charge(s} placed at the terminal of the electroscope neutralize the already present positive charges on the vanes by driving electrons down into them.

Experiment 5:
Charge two electroscopes simultaneously by induction

1. Set up both the electroscopes provided in the kit with disc terminals and arrange them side by side with terminals touching.

[Note: for best results, place electroscopes on a metal table top or on a piece of aluminum foil. Also make sure that they are completely discharged]

2. Bring a charged body (either a friction rod or an electrophorus) near the pair of electroscopes.

[Caution: Take care not to touch the terminals while handling; also, not to charge the electroscopes too much, beyond a 45 ° deflection of leaves.]

3. Watch the vanes diverge in both electroscopes, showing a charge in each.
4. Move the electroscopes apart.
5. Remove the charged body; and note that both vanes remain diverged. The electroscopes have been charged.
6. Test for the sign of the charge on each of them by bringing them together again so terminals touch. Observe that the leaves collapse.

[Caution: For results to be perfect, you might have to try repeatedly. Consider the possibility that accidental transfer of charge might have occurred by holding the charged body too close to the electroscope, as also leakage from it by accidental handling.]

7. You can conclude that the electroscopes acquired equal and opposite charges by induction.

Discussion:

The presence of the charged electrophorus induces a negative charge at the near end of the pair of electroscopes - the terminals and the vanes of the first electroscope thus acquiring a negative charge. The other electroscope acquires a positive charge, being at the far end. When the electroscopes are separated, the first electroscope is left with a net negative charge, whereas the other electroscope has a positive charge. And they retain the charge even after the source of charging is removed. Thus they have been oppositely charged.

Further, since electrons were neither added to nor taken away from the electroscopes, the charges they acquired must be equal. Since equal and opposite charges total to zero, it explains why the vanes collapse as the terminals touch again, when the electrons get redistributed.

Faraday's Ice Pail Experiment

1. Set up an electroscope with disc terminal; make sure it is discharged.
2. Place the Faraday's Pail (aluminum tumbler provided in the kit) on top of the disc terminal.
3. Charge an electrophorus and reserve it at a distance (where it will not affect the electroscope).
4. Charge a proofplane transfer ball by touching it to the electrophorus, and then lower it into the Faraday Pail carefully without touching its sides.
5. Observe the deflection of the electroscope vanes.
6. Withdraw the ball; note that the leaves collapse.
7. Reinsert the charged ball. Rotate it within the pail without touching its sides. Watch the leaves diverge to

the same extent for every direction the ball moves.

8. Now touch the ball to the inside of the pail; note that the deflection of the leaves remains unchanged.
9. Remove the transfer ball. Discharge it and use it to remove any charge from the outside of the pail (by touching it to the outside) and test it. Use the second electroscope for testing.
10. Repeat step 9, this time trying to remove any charge from the inside of the pail. The test identifies no charge on the transfer ball.

Conclusion:

Whatever charge was on the pail was not inside of it.

Discussion:

Why the deflection in the electroscope when the transfer ball is lowered into the pail? It is because the positive charge it carries draws electrons into the inside surface of the pail from its outside, by induction. The outside thus gets positively charged, which transfers to the vanes by conduction (electrons flow out of the vanes to the outside of the pail" and hence they diverge. The rotation of the transfer ball in the later step is no reason for the original deflection to change, since the ball has not altered its position relative to the sides of the pail.

Withdrawal of the ball restores the electrostatic equilibrium in the pail and in the vanes, since there was no actual transfer of electrons, but only a temporary reorientation of them.

When the charged ball is reinserted, it causes the vanes to diverge as before; however, touching the (negatively charged) inside of the pail with it will attract and remove the excess electrons from the inside and leave it neutral (discharged.)

So far the purpose of the experiment was to demonstrate how to charge just the outside of a metal pail by induction without affecting its inside.

The rest of the experiment verifies this for a fact. Discharged ball touching the outside of the pail gets some of its positive charge; and when it is taken to the second electroscope (which is previously positively charged) for charge identification, its vanes go further apart; this indicates additional positive charges coming (by induction) from the ball, which confirms the presence of positive charge on the outside of the pail.

On the other hand, the discharged ball picks up no charge from the inside of the pail and therefore not having any effect on the vanes of the test electroscope (previously charged as before); they neither diverge more nor collapse, indicating the total absence of charge on the ball, and therefore in the inside of the pail. (Review Experiment 3 if necessary.)

Helpful Tips and Reminders about Electrostatic Apparatus

Electrostatic charges are very small and voltages can be high. Therefore, charges can be conducted away by materials that you would ordinarily consider insulators/poor conductors. Some unreliable insulators are: wood, rubber, paper, leather, wool and cotton.

Water is a conductor of electricity. As films of water readily adhere to glass and minerals, and since the amount becomes larger at high humidities, glass, paper and wood are often poor insulators.

Finger prints and salt spray are electrically conductive. If contaminated, wash the electrophorus base and handle with distilled water. Do not, however, use soap or detergent.

A sheet of polyethylene film (from a garment bag or package) will generate a charge in almost any humidity condition, when rubbed against a piece of polystyrene or sulfur. In this sense, these materials are superior to fur, glass and hard rubber.

References:

1. Blackwood, O.H., Herron, W.B. and Kelly, W.C. High School Physics. Boston: Ginn & Company, 1961. (pp.400-423)
2. Cunningham, J. and Herr, N Hands-on Physics Activities. West Nyack, N.Y: Center for Applied Research in Education, 1 994. (pp.538-563).
3. Giancoli, D.C. Physics: Principles with Applications. (3rd.Ed.) Englewood Cliffs, N.J: Prentice-Hall, 1991 (pp 416-458).
4. Thurber, W.A. and Kilburn R.E. Exploring Physical Science. Boston: Allyn and Bacon, Inc. 1970 (pp 337-368).

How to Teach with Electroscopes Kit

Concepts Taught: Electrostatic Attraction and Repulsion; Electrostatic Conduction and Induction; Charge Identification. Charge distribution if a conductor; Electrostatic field

Curriculum Fit: Physics Sequence Electricity and Magnetism. *Static Charge.* **Grades 3-8**

Common Materials and their Performance as Charge Generators:

Excellent at all humidity conditions are:

Sulfur	Paraffin wax
Polystyrene	Polyethylene
Pure gum rubber	Vinyl plastic.

Excellent at low humidities are:

Porcelain	Glass
Mica	Acrylic plastic
Epoxy plastic	Polyester resins
Shellac	Bees wax.

Unreliable at moderate humidities are:

Wood products	Paper products
Hard rubber	Phenolic resins
Synthetic fibre fur	Cloth of all kinds
Soft glass	rubber

(Some rubber and plastic products are treated to make them slightly conducting).

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