Transfer of Electric Charge

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CHAPTER 1 Transfer of Electric Charge

- Describe how the transfer of electrons changes the charge of matter.
- Relate the transfer of electrons to the law of conservation of charge.
- Compare and contrast three ways that electric charge can be transferred.

Why is this girl's hair standing straight up? She is touching a device called a van de Graaff generator. The dome on top of the device has a negative electric charge. When the girl places her hand on the dome, she becomes negatively charged as well—right down to the tip of each hair!

Q: What causes the hair to stand on end?

A: All of the hairs have all become negatively charged, and like charges repel each other. Therefore, the hairs are pushing away from each other, causing them to stand on end.

Transferring Electrons

The girl pictured above became negatively charged because electrons flowed from the van de Graaff generator to her. Whenever electrons are transferred between objects, neutral matter becomes charged. This occurs even with individual atoms. Atoms are neutral in electric charge because they have the same number of negative electrons as positive protons. However, if atoms lose or gain electrons, they become charged particles called ions. You can see how this happens in the **Figure** 1.1. When an atom loses electrons, it becomes a positively charged ion, or cation. When an atom gains electrons, it becomes a negative charged ion, or anion.

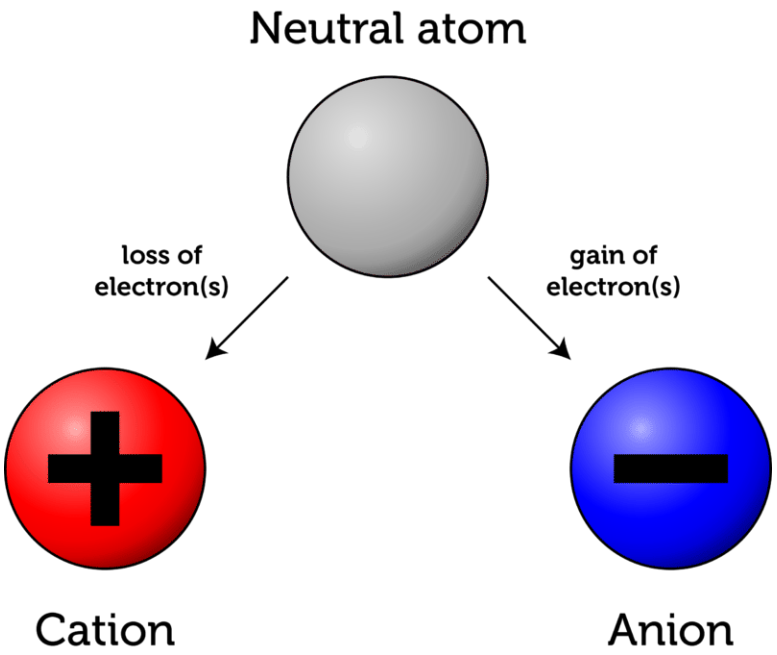

FIGURE 1.1

Conservation of Charge

Like the formation of ions, the formation of charged matter in general depends on the transfer of electrons, either between two materials or within a material. Three ways this can occur are referred to as conduction, polarization, and friction. All three ways are described below. However, regardless of how electrons are transferred, the total charge always remains the same. Electrons move, but they aren't destroyed. This is the **law of conservation of charge**.

Conduction

The transfer of electrons from the van de Graaff generator to the man is an example of conduction. Conduction occurs when there is direct contact between materials that differ in their ability to give up or accept electrons. A van de Graff generator produces a negative charge on its dome, so it tends to give up electrons. Human hands are positively charged, so they tend to accept electrons. Therefore, electrons flow from the dome to the man's hand when they are in contact.

You don't need a van de Graaff generator for conduction to take place. It may occur when you walk across a wool carpet in rubber-soled shoes. Wool tends to give up electrons and rubber tends to accept them. Therefore, the carpet transfers electrons to your shoes each time you put down your foot. The transfer of electrons results in you becoming negatively charged and the carpet becoming positively charged.

Polarization

Assume that you have walked across a wool carpet in rubber-soled shoes and become negatively charged. If you then reach out to touch a metal doorknob, electrons in the neutral metal will be repelled and move away from your hand before you even touch the knob. In this way, one end of the doorknob becomes positively charged and the other end becomes negatively charged. This is called polarization. Polarization occurs whenever electrons within a neutral object move because of the electric field of a nearby charged object. It occurs without direct contact between the two objects. The **Figure** 1.2 models how polarization occurs.

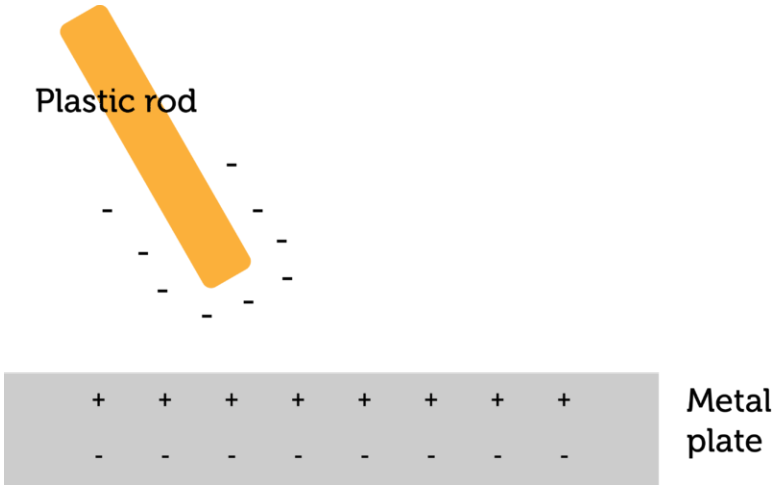

FIGURE 1.2

Q: What happens when the negatively charged plastic rod in the diagram is placed close to the neutral metal plate?

A: Electrons in the plate are repelled by the positive charges in the rod. The electrons move away from the rod, causing one side of the plate to become positively charged and the other side to become negatively charged.

Friction

Did you ever rub an inflated balloon against your hair? You can see what happens in the **Figure** 1.3. Friction between the balloon and hair cause electrons from the hair to "rub off" on the balloon. That's because a balloon attracts electrons more strongly than hair does. After the transfer of electrons, the balloon becomes negatively charged and the hair becomes positively charged. The individual hairs push away from each other and stand on end because like charges repel each other. The balloon and the hair attract each other because opposite charges attract.

FIGURE 1.3

Electrons are transferred in this way whenever there is friction between materials that differ in their ability to give up or accept electrons.

Q: If you rub a balloon against a wall, it may stick to the wall. Explain why.

A: Electrons are transferred from the wall to the balloon, making the balloon negatively charged and the wall positively charged. The balloon sticks to the wall because opposite charges attract.

Summary

- Whenever electrons are transferred between objects, neutral matter becomes charged. For example, when atoms lose or gain electrons they become charged particles called ions.
- Three ways electrons can be transferred are conduction, friction, and polarization. In each case, the total charge remains the same. This is the law of conservation of charge.
- Conduction occurs when there is direct contact between materials that differ in their ability to give up or accept electrons.
- Polarization is the movement of electrons within a neutral object due to the electric field of a nearby charged object. It occurs without direct contact between the two objects.
- Electrons are transferred whenever there is friction between materials that differ in their ability to give up or accept electrons.

Review

1. How is charge transferred by a van de Graaff generator?
2. Compare and contrast the formation of cations and anions.
3. State the law of conservation of charge.
4. Explain how conduction and polarization occur, using the example of walking across a wool carpet in rubber-soled shoes and then reaching out to touch a metal doorknob.
5. Predict what will happen to the charges of a plastic comb and a piece of tissue paper if you rub the tissue paper on the comb. (*Hint*: Plastic tends to accept electrons and tissue paper tends to give up electrons.)

Resources

MEDIA

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References

1. Christopher Auyeung. Ions are created by the loss or gain of electrons . CC BY-NC 3.0
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