

Electric charge

Electric charge is a property of matter that can cause attraction and repulsion. In this section, we focus on electrons and protons, and the role they play in causing an object to have an electric charge.

An electron is defined as having a **negative** charge and a proton is defined as having a **positive** charge. Charge is a scalar, not a vector. A negative charge is not less than zero, just the opposite of positive. In this book we will represent negative charges as black and positive charges as red.

The amount of charge of an electron or proton is written as e and is called the *elementary charge*. An electron has a negative charge of $-e$ and a proton has a positive charge of $+e$. This amount of charge is the smallest amount that has been isolated. (Subatomic particles called *quarks* have charges of $+2e/3$ or $-e/3$ but they have not been isolated.)

The SI unit for charge is the *coulomb*. An electron or a proton has a charge of magnitude $e = 1.602\ 18 \times 10^{-19}$ coulombs. This means approximately 6,250,000,000,000,000 electrons or protons are required for a coulomb of charge to be present. This is a vast number! However, numbers like this are often present in nature: A bolt of lightning typically contains about 25 C of charge. To provide you with another idea of the magnitude of a coulomb, approximately 0.8 C of charge flows through a 100 watt light bulb every second.

Some scientists, chemists in particular, use another unit, the *esu or electrostatic unit*. One esu equals $3.335\ 64 \times 10^{-10}$ C.

A small amount of matter contains a large number of electrons and protons. For instance, a one-kilogram sample of copper contains about 2.75×10^{26} protons. When an object has the same number of electrons and protons, it has no net charge and is said to be *electrically neutral*.

The addition or removal of electrons from an object causes it to become charged. A negatively charged object has more electrons than protons and a positively charged object has more protons than electrons. If the kilogram of copper has a charge of +0.1 C, which is a relatively large amount of charge, this means that about 0.000 002 % of its electrons have been removed.

How does an object become electrically charged? The answer is that the addition or removal of electrons creates negatively and positively charged objects. Except under extreme conditions, protons stay in place and electrons move.

A piece of silk and a glass rod can be used to demonstrate one manner in which objects can become charged. We will assume these two objects start out electrically neutral. In other words, the silk has equal numbers of protons and electrons, as does the glass.

You can transfer electrons from the glass to the silk by rubbing the two materials together. This close contact results in a net flow of electrons from the glass to the silk and causes the silk to become negatively charged. It now contains more electrons than protons. In turn, the glass becomes positively charged, since it now has fewer electrons than protons.

You may wonder why rubbing silk and glass together causes them to become charged. The electrons move because the silk molecules have a greater affinity for electrons than do the glass molecules. Rubbing the two materials together facilitates the transfer of electrons by providing a greater level of contact between their molecules.

The charging process can be reversed. When free to move, electrons will flow from a negatively charged object to a positively charged one, reducing or ending a charge imbalance. Lightning provides a dramatic example of such movement, a grand display of excess electrons moving to a region that is less negatively charged. With lightning, the electrons may be moving to a positively charged region of a cloud, or to an electrically neutral region such as the surface of the Earth. Charges take advantage of any opportunity to reduce an imbalance.

Questions:

- 1) What is the value on the elementary charge? Why is this called the elementary charge?**
- 2) What is the SI unit of electrical charge?**
- 3) Approximately how many electrons are needed to produce 1C?**
- 4) What does electrically neutral mean?**
- 5) How do you create charged objects?**