

Basic Atomic Theory, The Structure of Matter

The field of study we call **electricity** is the investigation of the forces created by **charged** particles, especially electrons, and the motion and interactions of those particles. The **electron** is a fundamental component of matter and is considered to have the smallest possible unit of **negative** charge. In comparison to ordinary visible objects in our environment, the electron is an extremely small particle, having a mass of only 9.109×10^{-31} kg.

Atomic Structure

All matter is composed of **atoms**, each of which has a central **nucleus** and one or more electrons that travel in orbits around the nucleus, like satellites around the earth. The nucleus contains one or more **positively** charged particles called **protons**. The positive charge of a proton is 'opposite' to the negative charge of an electron, in the sense that the total, or net, charge of the combination is zero. Thus, an atom that has the same number of electrons in orbit as it has protons in its nucleus is **electrically neutral**. The nucleus of every atom except that of hydrogen also contains one or more **neutrons**, which carry no electrical charge. The number of protons and neutrons in the nucleus of an atom uniquely determines the element it represents - iron, copper, oxygen, and so on - and all the atoms of a given element have identical nuclei.

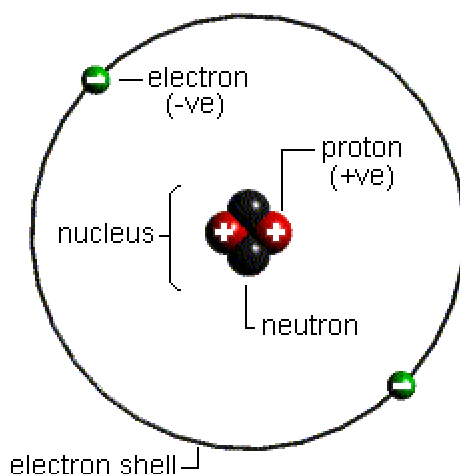


figure 741.1

Figure 741.1.1 is a diagram of the structure of the helium atom. Notice that the nucleus is a cluster of two protons and two neutrons and that there are two electrons in an orbit, called an **electron shell**, around the nucleus. The atom is electrically neutral because the two positively charged protons neutralize the two negatively charged electrons.

Atomic Forces

A very important fact that accounts for many of the electrical phenomena we will study in this site is that *there is a force of attraction between oppositely charged particles and a force of repulsion between similarly charged particles*. For example, two electrons in the vicinity of one another will each experience a force that drives them apart. An electron and a proton will each experience a force that draws them together. The following statement summarizes this behavior:

Like charges repel and opposite charges attract.

The magnitude of the force is inversely proportional to the square of the distance separating the charged particles. In short, the force increases dramatically when the particles are brought closer together. We can see in Figure 741.1.1 that there is a strong force of attraction between the orbiting electrons and the positive nucleus of the helium atom. The **dynamic** forces resulting from the orbital motion of the electrons counteract the attractive force of the nucleus and prevent the electrons from falling into the nucleus. This phenomenon is similar to that which keeps an earth satellite from falling out of orbit due to gravitational attraction.

Electron shells

The atoms of other elements contain additional electron shells that are farther removed from the nucleus than the electron shell shown in Figure 741.1.1. Figure 741.1.2 shows the electron shells that surround the nucleus of the copper atom. Each shell is designated by a letter (k, l, m, and n) and there is an upper limit on the number of electrons, which each shell can contain. If we regard the innermost (k) shell as shell number 1, the next (l) as shell number 2, and so on, the maximum number, M , of electrons that the n th shell can contain is given by the formula:

$$M = 2n^2 \text{ electrons}$$

(eqn 741.1.1)

Thus, the innermost shell can contain at most 2 electrons, the next shell, 8 electrons, the next shell, 18 electrons, and the fourth shell, 32 electrons. Equation 741.1.1 is valid for determining the number of electrons in any of the *first four* shells of an atom, but is not generally applicable for complex atoms containing additional shells.

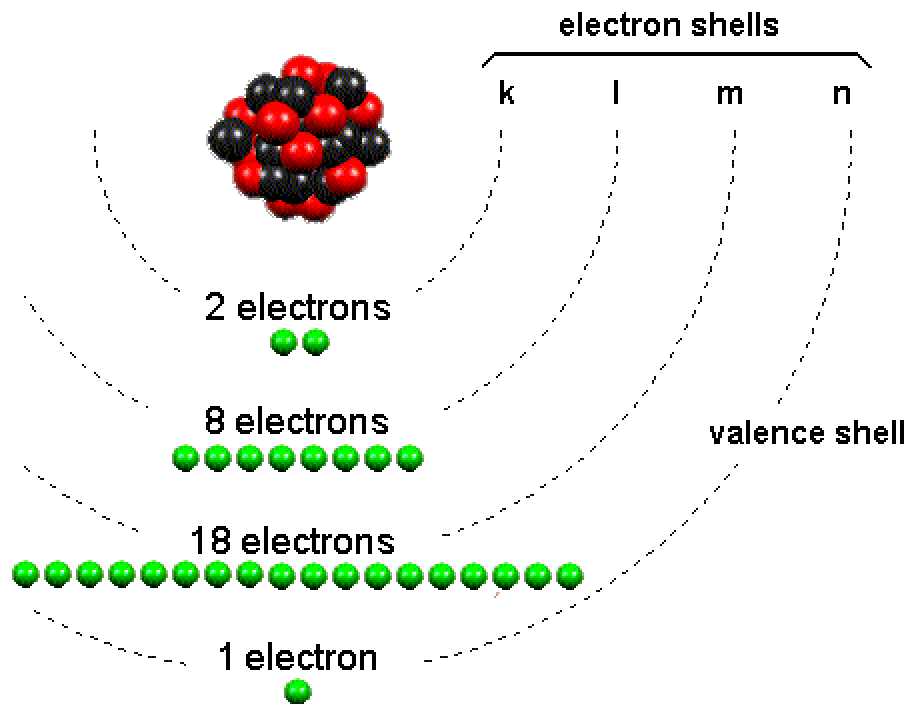


figure 741.1.2

Summary

- **Electricity** is the forces that arises from the motion of **electrons**
- All matter is composed of **atoms**
- An atom consists of a **nucleus** (containing **protons** and **neutrons**) orbited by **electrons**
- An electron is a **negatively** charged
- A proton is **positively** charged
- A neutron has **no** charge
- Like charges repel and opposite charges attract
- All atoms in an element (eg. oxygen, copper) contain an identical number of protons
- Atoms with an identical number of protons and electrons are electrically neutral
- Electrons in an atom arrange themselves into **shells** around the nucleus