Valence Electrons and how they work

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EECT 111 – Prof. Andy Bell

I found a book that provided a lecture by H.A. Lorentz where he describes the idea of valence electrons. He describes it in a 350 plus page lecture book from the early 1900’s. He describes it as follows:

“It is true in an electric field there is a certain state of things which gives rise to a force acting on an electrified body and which may therefore be symbolically represented by the force acting on such a body per unit of charge. This is what we call the electric force. It is by this necessity, that one has been led to the conception of electrons, i. e. of extremely small particles, charged with electricity, which are present in immense numbers in all ponderable bodies, and by whose distribution and motions we endeavor to explain all electric and optical phenomena that are not confined to the free ether. My task will be to treat some of these phenomena in detail, but I may at once say that, according to our modern views, the electrons in a conducting body, or at least a certain part of them, are supposed to be in a free state, so that they can obey an electric force by which the positive particles are driven in one, and the negative electrons in the opposite direction.

If, in a metallic wire, the electrons of one kind, say the negative ones, are travelling in one direction, and perhaps those of the opposite kind in the opposite direction, we have to do with a current of conduction, such as may lead to a state in which a body connected to one end of the wire has an excess of either positive or negative electrons. This excess, the charge of the body as a whole, will, in the state of equilibrium and if the body consists of a conducting substance, be found in a very thin layer at its surface. In a ponderable dielectric there can likewise be a motion of the electrons. Indeed, though we shall think of each of them as having a definite position of equilibrium, we shall not suppose them to be wholly immovable. They can be displaced by an electric force exerted by the ether, which we conceive to penetrate all ponderable matter, a point to which we shall soon have to revert. Now, however, the displacement will immediately give rise to a new force by which the particle is pulled back towards its original position, and which we may therefore appropriately distinguish by the name of elastic force.

A substance in which the electrons are shifted to new positions is said to be electrically polarized.

Again, under the influence of the elastic forces, the electrons can vibrate about their positions of equilibrium. In doing so, and perhaps also on account of other more irregular motions, they become the centers of waves that travel outwards in the surrounding ether and can be observed as light if the frequency is high enough. In this manner we can account for the emission of light and heat. As to the opposite phenomenon, that of absorption, this is explained by considering the vibrations that are communicated to the electrons by the periodic forces existing in an incident beam of light. If the motion of the electrons thus set vibrating does not go on undisturbed, but is converted in one way or another into the irregular agitation which we call heat, it is clear that part of the incident energy will be stored up in the body, in other terms that there is a certain absorption. Nor is it the absorption alone that can be accounted for by a communication of motion to the electrons.

The fundamental idea of the modern theory of the thermic and electric properties of metals is, that the free electrons in these bodies partake of the heat-motion of the molecules of ordinary matter, travelling in all directions with such velocities that the mean kinetic energy of each of them is equal to that of a gaseous molecule at the same temperature. If we further suppose the electrons to strike over and over again against metallic atoms, so that they describe irregular zigzag-lines, we can make clear to ourselves the reason that metals are at the same time good conductors of heat and of electricity, and that, as a general rule, in the series of the metals, the two conductivities change in nearly the same ratio. The larger the number of free electrons, and the longer the time that elapses between two successive encounters, the greater will be the conductivity for heat as well as that for electricity.”

So in lay terms, the outer electrons in the valence layer are free to move. Therefore they repel each other and create electricity. Based on Lorentz statement about the electrons it appears that the more electrons in the valence, outer, layer the longer it takes for the repelling actions to take place. So that puzzled me and then I found a statement where it talks about the valence shell. They specifically talk about a copper atom.

This is from the National Destructive Resource Center:

“Notice that in the copper atom pictured below that the outside shell has only one electron. This represents that the copper atom has one electron that is near the outer portion of the atom. The outer shell of any atom is called the valence shell. When the valence electron in any atom gains sufficient energy from some outside force, it can break away from the parent atom and become what is called a free electron.



Pictured here is an atom of copper, which is much more complex than either an atom of hydrogen or helium.

Atoms with few electrons in their valence shell tend to have more free electrons since these valence electrons are more loosely bound to the nucleus. In some materials like copper, the electrons are so loosely held by the atom and so close to the neighboring atoms that it is difficult to determine which electron belongs to which atom. Under these conditions, the valence or free electrons tend to drift randomly from one atom to its neighboring atoms. Under normal conditions the movement of the electrons is truly random, meaning they are moving in all directions by the same amount. However, if some outside force acts upon the material, this flow of electrons can be directed through materials and this flow is called electrical current. Materials that have free electrons and allow electrical current to flow easily are called conductors. Many materials do not have any free electrons. Because of this fact, they do not tend to share their electrons very easily and do not make good conductors of electrical currents. These materials are called insulators.”

So the information I found details why free electrons in the outer layer help to carry electricity. What I find interesting is that with fewer free electrons the better the conductor,

Resources: National Destructive resource center: NDT-ED.org

Electrons; Electromagnetic theory and Radiation; Author: Lorentz, H. A. (Hendrik Antoon); Publisher: Leipzig : B.G. Teubner ; New York : G.E. Stechert 1907; Call number: nrlf\_ucb:GLAD-117490993