Pearson

19.1: Lightning and Batteries

Lightning dramatically demonstrates the power of the flow of electrical charge. Many of the same principles, although in a much more controlled environment, are at work in a standard flashlight battery. The driving force for both lightning and the battery is the same, and we have encountered it before: electrons flow *away* from negative charge and toward *positive* charge.

In a thundercloud, violent air currents cause water droplets and ice particles to collide. The collisions knock electrons off of molecules, creating positive and negative charges. The positive charges accumulate on small ice crystals that travel to the top of the thundercloud on rising air currents. The wet slushy bottom of the thundercloud becomes negatively charged. The resulting charge separation exists until a conductive path can form between the bottom of the cloud (negatively charged) and the top of the cloud (positively charged). The conductive path forms when the charge separation is so great that a channel of ionized air develops. This channel acts like a conductive wire, allowing a massive amount of charge to flow through it in order to equalize the charge separation. The massive flow of electrical charge is lightning.

Most lightning occurs within the thundercloud itself or from one thundercloud to another. However, if the thundercloud gets close enough to the ground, the earth underneath the cloud develops a positive charge in response to the negative charge at the base of the cloud. The channel of ionized air can then form between the cloud and the ground, resulting in the flow of charge from the base of the cloud to the earth in what is called cloud-to-ground lightning. Cloud-to-ground lightning is visible and dramatic to observers on the ground.

Batteries operate on many of the same principles at work in lightning. A battery is composed of substances that have different affinities for electrons. The substances are separated so that one end of the battery develops a positive charge and the other end develops a negative charge. The charge separation exists until a conductive path connects the two ends, providing a path through which charge can flow. A metal wire, with a light bulb in line, can provide such a path. When the wire is connected, electrons flow from the negative end of the battery—through the wire and through the light bulb—to the positive end. As the electrons flow through the filament of the light bulb, they create heat and light, much like the flow of electrons from a thundercloud to the earth produces heat and light in a much more dramatic form.