Up in Flames

Exploring the Interaction of Light and Electrons

MATERIALS

Bunsen burner
calculator, graphing
copper(II) nitrate, 0.5 M
7 cotton swabs, individual
crucible tongs
spectroscope, hand-held
barium nitrate, 0.5 M
calcium nitrate, 0.5 M
lithium nitrate, 0.5 M
potassium nitrate, 0.5 M
sodium nitrate, 0.5 M
strontium nitrate, 0.5 M

Back in the 18th century, chemists began using flame tests to identify and distinguish elements. Different elements produce different colored flames when placed in the fire of a Bunsen burner. The different colors of flames are produced by electrons moving between energy levels and are useful in identifying an element.

Many of the flame colors appear similar when viewed in a dark room. To get a more detailed view of the flame, a *spectroscope* can be used to separate the colored light into distinct colored bands. Like a prism, the spectroscope bends the light waves differently depending on their wavelength. Long-wavelength red light is bent the least, and short-wavelength violet light is bent the most. The combination of colored lines produced by the spectroscope is called the **atomic line spectra** and is unique, like a fingerprint, for each element.

Neils Bohr studied the atomic line spectra for hydrogen and investigated the relationship between the line spectra and the structure of the atom. He proposed that electrons in an atom can only have specific energy values, called **energy levels**, and that electrons could jump up to a higher level only when they absorbed a photon of light that exactly matched their energy value. By exciting the electrons of an atom with energy from a Bunsen burner, we cause electrons to jump to a higher energy level.

At some point, the electrons will lose that excess energy and fall back to their lower, ground state energy level. It is the emission of this excess energy that results in the colored bands on the atomic line spectra. Each colored line represents a transition between a particular pair of energy levels. For example, a red line might indicate a transition between energy levels 2 and 3 whereas a violet line may indicate a transition between energy levels 2 and 6. The energy of these lines can be calculated from their wavelengths and will give us a picture of how the different energy levels are structured within the atom.