Experiment 3: ATOMIC SPECTROSCOPY

In this experiment you will construct a simple but fairly accurate spectroscope containing a built-in quantitative calibration system. The spectroscope will be used to obtain various atomic line spectra and the wavelength and energy of emitted light.

This experiment provides an opportunity for you to make basic observations which are similar to those which helped form the foundation of modern atomic structure theory. Prior reading of the chapter of your general chemistry text dealing with atomic spectra is necessary to support your understanding of this experiment. In turn, the experiment will support your understanding of atomic theory.

As you have learned, atoms and molecules contain electrons that occupy discrete energy levels. The actual energy of each state (level) is dependent upon several factors: the nuclear charge, the distance of the electron from the nucleus, and the number of electrons between the nucleus and the electron in question. Because these various factors are different for every atom or molecule, it follows that the energy levels are unique for any given atom or molecule.

The transition of an electron from one level to another must be accompanied by the emission or absorption of a discrete amount of energy. The magnitude of this energy depends on the energy of each of the levels between which the transition occurs. The relationship between energy and light radiation was proposed by Einstein in 1905 and is represented by eq 1

$$\Delta E = E_2 - E_1 = h\nu = hc/\lambda \qquad (1)$$

where:

ΔE = change in energy from the excited state (state 2) to the ground state (state 1)

h = Planck's constant (6.63×10^{-34} J·s)

c = the velocity of light in a vacuum (3.00×10^{8} m/s)

ν = the frequency (Hz) of the observed light

λ = the wavelength (m) of the observed light

The atomic spectra that are observed for the excited atoms consist of radiation given off as electrons cascade down from higher to lower energy levels. The number and type of these transitions depend on the particular structure of the energy levels in a given chemical species and on various quantum selection rules. The emission spectra are characteristic of specific gaseous atoms or molecules whether observed in the laboratory, your home town, or on another planet. In other words, each element produces its own characteristic emission spectrum. If the value of ΔE lies within the visible region of the electromagnetic spectrum, then the frequency corresponds to visible light, and the emission can be seen by the eye. The wavelength of emitted light can be measured using a spectroscope. Then, using eq 1, we can calculate the amount of energy released for various transitions and so "map" the energy levels available to the electrons in the atom.

The separation of light into its spectral components can be done by *refraction* or *diffraction*. In this laboratory experiment, the separation of light into its component colors is accomplished by diffraction in a device called a *spectroscope*. A spectroscope is simply a box, with a slit at one end (to let light in) and a light-separating device at the other end. The separating device you will be using is called a *transmission diffraction grating*, and it consists of