Atomic Spectra and the Rydberg Constant

# Introduction

Atoms and molecules can absorb energy by many different methods and later emit it in the form of light. An incandescent light bulb converts electrical energy into heat and the hot wire re-radiates the energy as light. Fluorescent light bulbs, on the other hand, absorb electrical energy but the internal volume of a fluorescent bulb is a rarified gas. Electrons are accelerated by high voltage through the bulb and individual electrons collide with individual atoms, transferring a large amount of energy to a gaseous atom as a "packet".

Whenever an atom releases energy by collisions with nearby neighbors, all colors of light are produced; but when an atom absorbs and releases energy in isolation, only a certain set of discrete frequencies are absorbed and released. Spec­trosco­py is the study of light frequencies absorbed and released by atoms and molecules, which is the characteristic spectrum of an atom or molecule.

The different spectra of atoms were very confusing before 1900, because there seemed to be no mathematical relationship between the lines produced by different atoms, nor any relationship between atomic spectra. In 1885 J.J. Balmer discovered an equation that predicted the line spectrum of the smallest atom with the simplest spectrum: hydrogen.

The formula is given as:

f = RH (1/4 - 1/n2)

where f is the frequency of light, RH is called the Rydberg constant, and n is an integer larger than 2: n = 3, 4, 5, ...

In this activity, qualitative observations will be made of atomic spectra using both flame spectroscopy and discharge tubes. We will also verify Balmer’s relation and estimate the Rydberg constant by carefully measuring the wavelength of the three visible lines of the hydrogen spectrum.

# Materials and Methods

* 0.5 M or 0.2 M Potassium Nitrate – Oxidizer, Mutagenic, Toxic
* 0.5 M or 0.2 M Barium Nitrate – Oxidizer, Marine Pollutant, Toxic
* 0.5 M or 0.2M Sodium Nitrate – Oxidizer, Marine Pollutant
* 0.5 M or 0.2 M Calcium Nitrate - Oxidizer
* 0.5 M or 0.2 M Strontium Nitrate – Oxidizer, Marine Pollutant
* 0.5 M or 0.2 M Cupric Nitrate – Oxidizer, Mutagenic, Marine Pollutant

# Procedure

Part I: Flame Spectroscopy

A metal chloride solution will be at each station next to a Bunsen burner. Dip the wire loop in the solution and heat it in the flame. Record the color of the flame.

Part II: Discharge Tubes

Diffraction gratings will be available for viewing atomic spectra. Sketch the spectra of helium, neon, oxygen, and hydrogen on the report sheet. Note both the relative positions of the lines and their relative intensities. Attempt to describe or characterize each spectrum briefly with words.

Part III: The Rydberg constant

Use a very accurate spectrometer to determine the wavelengths of visible light produced by the hydrogen atom. Record the measurements in the table on the Report Sheet, assuming the red line corresponds to n=3, the green line is n=4, and the violet line is n=5.

Make a graph of frequency vs. 1/n2. Find the value of the Rydberg constant from both the slope of the straight line and the Y-intercept.