Exp. 12: Diffraction Grating

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30 November 2023

Abstract

The purpose of this experiment was to analyze the energy levels of blue and green light when filtered through glass diffraction grating. The energy of the different colored photons could be calculated with the expression (12.4 x 103 Å⋅eV)/λ. Using this formula, the values of the blue and the green photon’s energy were calculated to be 2.84 and 2.25 electron volts, respectively.

Introduction

A diffraction grating is a series of slits with a spacing of *d* between the slits. When parallel light passes through the grating, spectral lines with wavelengths, λ, will be visible through a telescope. There is an optical path difference represented by the formula δ = d sin θ that exists between adjacent rays. When δ is a multiple of one of the wavelengths of the light, it creates constructive interference. This makes a particularly bright spectral line at the angle represented by θ. Thus, pλ = d sin θ. A photon’s energy can be calculated by the formula E = hc/λ, with h referring to Plank’s constant and c referring to the speed of light. This means that the energy of a photon, in electron volts, can be represented by the formula (12.4 x 103 Å⋅eV)/λ.

Procedure

For this experiment, a telescope was set up to view the light passing through a diffraction grating. On the base of the telescope were degree markings. Using these markings, the angle of the central maximum was measured. The telescope was then rotated until it was centered on bright blue line for the first order on both sides of the maximum. For each line, the angles on either side were averaged using the degree markings on the base. The wavelength could then be calculated using the previously mentioned formula. This process could then be repeated for the second order blue line, and the values for both wavelengths could be averaged. The entire procedure could then be used to calculate the wavelength of the green line. These wavelengths were then used to calculate their corresponding energies. These energies correspond to differences between a mercury atom’s energies. By summing the photon’s energy with the various mercury energy levels, a matching energy level to one of the values could be found, showing us the two levels of the transition.

Results

The energy of the blue and the green photons were calculated to be 2.8411 and 2.2503 electron volts, respectively. The blue photon corresponds to a transition between the 6p3P1 and the 7s3S1 levels of Mercury. This had a percent difference of 0.04%. The green photon corresponds to a transition between the 6p3 P2 and the 7s3S1 levels of Mercury. This had a percent difference of 0.3%.

Questions to be Answered:

1. Yes, because our eyes can act as the lenses necessary to see the spectra.
2. They would have to be between 4.3 and 9.9 lines/mm off. (See formula on excel sheet).
3. The grating is facing the telescope. It does not matter which way the grating is facing because the lines would be visible either way.