Bright-Line Emission Spectra

* **Question:** How does energy change impact the transition of electrons between energy levels?
* **Introduction:** As early as 1752, the first clues to understanding atomic structure appeared when scientists began to study the emission and absorption of light from different elements. Early in the twentieth century, Rutherford was able to provide some detailed explanation of the observed spectra of some elements. From this study came the introduction of spectroscopy and the development of spectral analysis.

An instrument used to detect and study the emission spectra of various substances is called a **spectroscope**. A spectroscope is a simple instrument which contains a prism or diffraction grating. The prism or diffraction grating separates the light emitted from a substance into specific energies. The apparatus used in this experiment is a simple spectroscope.

When an atom or molecule gains or loses energy, this energy is transferred to and from atoms or molecules in definite discrete units of radiant energy called **photons** or **quanta**. The energies of electrons in an atom or molecule are restricted to definite quantities, called energy levels. These energy levels are fixed for a given atom and to change the energy state, a photon must be emitted or absorbed. In other words, an electron must move from one energy level to another. The lines in the spectrum represent amounts of energy emitted when excited electrons move from one energy level to another. Sodium, as an example, has two closely spaced lines.

In the previous lab you observed the different colors of metals by flame tests. In this lab you will discover that the spectrum of an element is characteristic of that element. You will study the spectra of different elements and calculate the frequency of spectral lines bases upon wavelength.

* Safety: Bulbs are HOT! Do not touch. Black power boxes are high energy! Do not stick your fingers in the sockets.
* **Procedure:** (✓ each of the steps as you complete them.)
* 1. Look through the diffraction grating at the narrow end of the spectroscope pointing the slit towards the light source to be analyzed. The spectrum will appear on the right side of the slit below the scale where the wavelengths of the emission lines can be read. The visibility of the spectrum can be improved by holding the hand around the narrow end of the spectroscope using the thumb and index finger to keep stray light from around the eye.
* 2. Observe and record (Draw what you see)
* 3. Repeat until you have observed the other gas discharge tubes and the incandescent light bulb

**Data Table**

**(DO NOT COPY INTO LAB NOTEBOOK – Color directly onto this sheet)**

Incandescent Light Bulb

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| ׀  7  ׀ | ׀  6  ׀ | ׀  5  ׀ | ׀  4  ׀ |

Hydrogen

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| ׀  7  ׀ | ׀  6  ׀ | ׀  5  ׀ | ׀  4  ׀ |

Neon

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| ׀  7  ׀ | ׀  6  ׀ | ׀  5  ׀ | ׀  4  ׀ |

Mercury

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| ׀  7  ׀ | ׀  6  ׀ | ׀  5  ׀ | ׀  4  ׀ |

Helium

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
| ׀  7  ׀ | ׀  6  ׀ | ׀  5  ׀ | ׀  4  ׀ |

* **Calculations:**

1. For each of the visible spectral lines of hydrogen’s bright-line emission spectrum, calculate the **frequency** of this color. (Identify each by the name of the color).

*Frequency and wavelength are mathematically related to each other. For electromagnetic radiation, this relationship is written as follows: c = λν*

*C is the speed of light = 3.00 x 108 m/s*

*λ (lambda) is the wavelength of the electromagnetic wave in m*

*ν (nu) is the frequency of the electromagnetic wave in Hz*

2. Using the frequency for each of the visible spectral lines of hydrogen’s bright-line spectrum, calculate the **energy** of a photon of this particular color.

*E = hν*

*E is energy in joules (J)*

*h is Planck’s constant (6.626 x 10-34 J·s)*

* **Conclusion:**

*“Using the Energy of a Photon formula,* ***E = hν****, and the calculated frequency of each of hydrogen’s visible spectral lines the energy of a photon of the colors \_\_\_\_\_\_\_\_\_\_\_\_\_\_ , \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ were calculated to be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ , \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ respectively.”*

EXTRA CREDIT: Compare and contrast the spectrum of the incandescent light bulb with the others. What accounts for the difference?