Heading

Emission Spectrum Lab

**Introduction**

**Purpose** To understand the quantum nature of atomic structure by determining the wavelengths and energy associated with specific spectral lines of several elements.



**Discussion**

The energetics and wavelength related to electrons in atoms can be observed using absorption and emission spectra. One convenient method of exciting the atoms of an element is to pass an electric current through a sample of the element in the vapor phase. This is the principle behind the spectrum tubes used in this lab.

Gas spectrum tube

High voltage transformer

A spectrum tube contains a small sample of an element in the gaseous phase. An electric discharge through the tube will cause the vapor to glow brightly. The glow is produced when excited electrons emit radiant energy as they return to their original levels.

When visible radiant energy from a spectrum tube is passed through a diffraction grating, a bright-line spectrum is produced due to interference of waves. Each element has its own unique emission spectrum by which it can be identified (e.g. fingerprints). Such a spectrum consists of a series of bright lines of definite wavelength. Each wavelength can be mathematically related to a definite quantity of energy produced by the movement of an electron from one discreet energy level to another. Thus, emission spectra are experimental proof that electrons exist at definite, distinctive energy levels in an atom.

**Hypothesis**

?

**Materials**

Emission Spectrum Device Gas Spectral Tubes of Unknown Elements

1 x 4” strips of unlined paper Colored pencils or colored markers

Diffraction Gratings Metric Ruler

Diffraction Box with Slits DIFFRACTION GLASSES

<http://somup.com/cr1ooeqp6w> Emission Spectra Lab (2:33)

**Procedures**

Paper strip

Diffraction grating

Slit



1. Spectral lines can be observed and measured using a diffraction box like the one shown.

* The box has one slit on each end and a diffraction grating attached to one of the slits as shown.
* A piece of white paper is attached adjacent to the slit in the box opposite the diffraction grating to mark the colors observed.
* The observer looks through the diffraction grating at one end of the box, through the slit at the opposite end of the box and lines up with the gas spectrum tube on the high voltage transformer.

2. The goal of this lab is to calculate the wavelength (λ) in cm for each of the spectral lines observed on the paper strip and eventually the energy released by the electron in giving off a particular color. The diagram below shows the trigonometry necessary to calculate the wavelength. Scientists determined that the wavelength of each color observed is calculated by λ = “d” x sin θ where “d” is the distance between each line of the diffraction grating.

θ

X

Y

Z

slit

Diffraction Grating



3. The angle “θ” can be calculated using tan θ = X/Y. Therefore, **θ = tan-1 X / Y**.

a. **X** represents the distance from the center of the slit to each spectral line (X1, X2, X3, etc.).

b. **Y** represents the length of the diffraction box used.

4. X, Y, and Z are three sides of a right triangle where Z is the hypotenuse … Z2 = (X2 + Y2).

5. “**d**” is the distance between each line (split) of the diffraction grating with the value of **1.9 x 10-4 cm**.

6. You will use the given values of “X” and “Y” to calculate the angle “θ”, sin θ, and λ = “d” x sin θ.

7. Compare your values to the chart of accepted values.

8. Watch the video: <http://somup.com/cr1ooeqp6w> Emission Spectra Lab (2:33) and complete the Observation Chart below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element  (add name) | Distance (X) of spectral lines in cm | | Color  of spectral line | Length (Y)  of box in cm |
|  | | | | |
| #1 | X1 | 6.48 cm |  | Y = 27.55 cm |
| X2 | 7.29 cm |  |
| X3 | 10.14 cm |  |
|  | | | | |
| #2 | X1 | 7.02 cm |  | Y = |
| X2 | 7.68 cm |  |
| X3 | 8.95 cm |  |
| X4 | 10.35 cm |  |
|  | | | | |
| #3 | X1 | 6.50 cm |  | Y = |
| X2 | 8.27 cm |  |
| X3 | 9.42 cm |  |

**Calculations and Data**

1. Use the Observation Chart to complete the spectral Summary Chart for elements 1-3.

2. Transfer the color for each spectral line from the Observation Chart.

3. Show work for ONE of the spectral lines for each element. Include the work to find θ, sin θ, and λ.

4. Based on the video, draw in color lines to represent the spectral lines (X1, X2, etc.).

**Summary Chart Element #1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element Name | Color of Spectral Line | θ in cm  θ = tan-1 X/Y | sin θ | Wavelength λ = *d x sin θ* | |
| cm | nm |
| #1 | X1 |  |  |  |  |
| X2 |  |  |  |  |
| X3 |  |  |  |  |
| *Draw (in color) the spectral lines for Element 1.* | | | | | |

Show Work for ONE spectral line above:

**Summary Chart Element #2**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element Name | Color of Spectral Line | θ in cm  θ = tan-1 X/Y | sin θ | Wavelength λ = *d x sin θ* | |
| cm | nm |
| #2 | X1 |  |  |  |  |
| X2 |  |  |  |  |
| X3 |  |  |  |  |
| X4 |  |  |  |  |
| *Draw (in color) the spectral lines for Element 2.* | | | | | |

Show Work for ONE spectral line above:

**Summary Chart Element #3**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element Name | Color of Spectral Line | θ in cm  θ = tan-1 X/Y | sin θ | Wavelength λ = *d x sin θ* | |
| cm | nm |
| #3 | X1 |  |  |  |  |
| X2 |  |  |  |  |
| X3 |  |  |  |  |
| *Draw (in color) the spectral lines for Element 3.* | | | | | |

Show Work for ONE spectral line above:

**Conclusions and Questions**

1. What major principle of light is demonstrated in this laboratory?

2. Explain why there are definite spectral lines for the emission spectrum of a gas using the terms frequency or wavelength, constructive interference and “in phase.”

3. What is the difference between an emission spectrum and an absorption spectrum for a gas?

4. Draw a diagram of diffraction of light which represents how the emission spectra you saw in this lab were produced.

5. Compare your results to the Spectral Analysis Chart (next page) to confirm you identified the unknown elements. Label the elements in the Observation Tables and Summary Table of your Calculations and Data section.

Emission Spectra Information

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Element** | **Red** | **Orange** | **Yellow** | **Green** | **Blue** | **Violet** |
| Wavelengths are given in nanometers (10-9 m) | | | | | | |
| Argon |  |  |  |  | 451 | 435 427 420 410 |
| Helium | 706 667 |  | 588 |  | 502 469 | 390 |
| Hydrogen | 656 |  |  |  | 486 | 434 410 |
| Lithium | 670 | 610 |  |  | 498 460 |  |
| Mercury | 734 691 | 615 | 580 577 | 546 |  | 435 405 |
| Neon | 725 718 693 | 640 | 588 585 | 540 532 | 479 470 458 |  |

Follow up Activity

Emission Spectra Energy Levels

* Complete the chart below to convert the wavelengths to frequency for each spectral line. (speed of light, c = 3.00 x 108 m/s)
* Then, calculate the amount of energy for an electron that produced the emission spectrum for one element in the lab. (Planck’s constant, h = 6.63 x 10-34 Js)
* Convert your Energy (j) calculations into electron Volts (eV) using: 1.6 x 10-19 j = 1 eV.
* Show work for all calculations of ONE spectral line in each element chart.

##### c = f λ f = c / λ E = h c / λ E = hf

**Element #1 (\_\_\_\_\_) Energy Chart**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Wavelength  (nm) | Wavelength  (m) | Frequency (Hz)  [*f = c / λ*] | Energy (j)  [*E = hf*] | Energy (eV)  [*E / 1.6 x 10-19*] |
| X1 |  |  |  |  |  |
| X2 |  |  |  |  |  |
| X3 |  |  |  |  |  |

**Element #2 (\_\_\_\_\_) Energy Chart**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Wavelength  (nm) | Wavelength  (m) | Frequency (Hz)  [*f = c / λ*] | Energy (j)  [*E = hf*] | Energy (eV)  [*E / 1.6 x 10-19*] |
| X1 |  |  |  |  |  |
| X2 |  |  |  |  |  |
| X3 |  |  |  |  |  |
| X4 |  |  |  |  |  |

**Element #3 (\_\_\_\_\_) Energy Chart**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Wavelength  (nm) | Wavelength  (m) | Frequency (Hz)  [*f = c / λ*] | Energy (j)  [*E = hf*] | Energy (eV)  [*E / 1.6 x 10-19*] |
| X1 |  |  |  |  |  |
| X2 |  |  |  |  |  |
| X3 |  |  |  |  |  |