**AP Physics: Lab #13**

**Analyzing Atomic Spectra**

Name _____ Hour _____

Lab Partners _____

## Purpose:

* Use a diffraction grating to create a spectroscope.
* Observe and analyze the emission spectra of gas lamps.
* Identify elements through their characteristic emission spectrum.

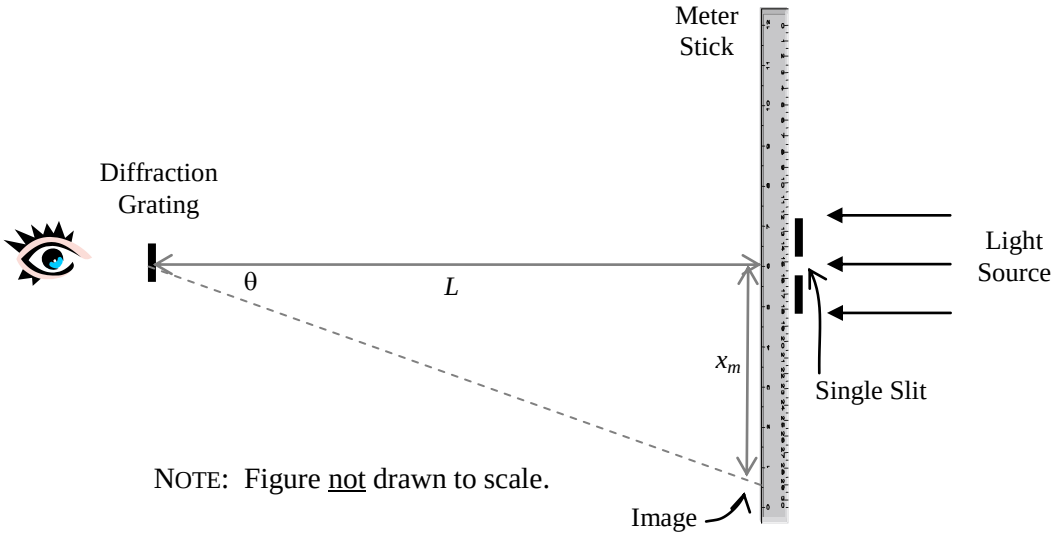
## Equipment:

Gas Lamps
Large single slit
Meter stick
Diffraction grating of known width

## Introduction:

When light is observed through a diffraction grating, individual rays pass through the grating at all angles. If these rays of light are in phase as they pass through the grating, an image of the light is formed by the eye. The location of this image can be found using interference properties, according to the equation:

$$d \cdot \sin\theta = m \cdot \lambda$$




NOTE: Figure <u>not</u> drawn to scale.

## Procedures:

***(CAUTION: Safety procedures <u>must</u> be followed when working with the gas lamps. Do not touch the supply electrodes while the supply is turned on.)***

Position the helium gas lamp at one end of the lab table. Attach the single slit to the gas lamp, making sure that the slit is directly over the bright portion of the lamp, so that light from the lamp is emitted in a single bright beam through the slit. Place the meter stick in front of the gas lamp, so that the middle of the meter stick is directly below the bright beam from the lamp, as shown in the diagram above. Mount the diffraction grating at the opposite end of the lab table, at approximately the same height as the bright beam from the gas lamp.

## Procedures: *(cont)*

Turn on the helium gas lamp. Look directly through the diffraction grating at the slit, while a lab partner makes very fine adjustments in the position of the gas lamp. Proper alignment is achieved when the slit is as bright as possible when seen by the person looking through the grating directly at the slit. When the positions of the gas lamp and the diffraction grating have been properly adjusted, an image of the spectrum of the gas should be present to the right and to the left of the slit itself. If necessary, adjust the angle of the grating so that the spectrum appears at approximately the same distance on the right and left sides.

Look through the diffraction grating, noting the position and color of each line present in the helium spectrum image. A lab partner should measure the distance from the slit to the image by moving a small pointer along the meter stick until it is at the position of the image seen by the person looking through the diffraction grating.

Record the color of each helium spectrum line and the positions of its $1^{st}$ order spectra on the right and left sides on Data Table A. Repeat the procedures for two additional unknown gas lamps, recording your data on Data Tables B and C.

## Calculations:

Calculate the average distance between the single slit and the left and right images for each emission line of each gas lamp.

Use the average distance between the single slit and the left and right fringes to calculate the angle and wavelength for each emission line. *(HINT: Avoid the small angle approximation for diffraction grating calculations.)*

Use the wavelengths of each emission line to determine the gas in each of the two unknown lamps. The unknown gases may be any of the following: Argon, Hydrogen, Mercury, Neon, or Sodium. You may wish to use the atomic spectra at the web site http://jersey.uoregon.edu/vlab/elements/Elements.html to help identify the unknown gases.

## Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- When you have identified the hydrogen gas lamp, use the wavelengths given in your textbook to calculate a percentage error for each emission line. What do you think the main sources of error in this experiment are?
- Draw and label an energy level diagram for hydrogen. Calculate the energies of each of the emission lines observed in the hydrogen sample. Clearly mark transition lines on your energy level diagram for photons of each wavelength of light observed.
- Could this experiment have been performed using a double slit instead of a diffraction grating? What difficulties might you encounter in such an experiment?
- What was the shortest wavelength of light observed in this experiment? What element spectra included this wavelength? Calculate the energy of a photon in that emission line.
- What was the longest wavelength of light observed in this experiment? What element spectra included this wavelength? Calculate the energy of a photon in that emission line.

## Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 5 pts
Calculations – 7 pts
Analysis – 12 pts

Laser - Screen Distance *(L)* = _____ Slit Separation *(d)* = _____

Data Table A: Helium

| Color | Position - L ($x_L$) | Position - R ($x_R$) | Position - Avg ($x$) | Angle ($\theta$) | Wavelength ($\lambda$) |
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Data Table B: Unknown #1

| Color | Position - L ($x_L$) | Position - R ($x_R$) | Position - Avg ($x$) | Angle ($\theta$) | Wavelength ($\lambda$) |
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Unknown Element #1 = _____

Data Table C: Unknown #2

| Color | Position - L ($x_L$) | Position - R ($x_R$) | Position - Avg ($x$) | Angle ($\theta$) | Wavelength ($\lambda$) |
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Unknown Element #2 = _____