LAB: SPECTROSCOPY

THE SPECTROMETER - MEASURING THE UNIVERSE WITH COLOR

Isaac Newton discovered that when sunlight passed through a piece of glass with non-parallel sides (a prism) the colors of the rainbow (a spectrum) came out the other side. When a prism, used in a device called a spectrometer, is connected to the end of a telescope, the spectrum of a star can be studied. Analyzing the spectrum can lead to information about the chemical composition of the star (or planet or galaxy).

Another device for separating the light from a source into its spectrum is a diffraction grating. The grating consists of a transparent material onto which hundreds of lines per centimeter have been etched. As the light passes through these lines, different wavelengths of light (different colors) are bent at different angels. Many modern spectrometers make use of grating instead of prisms.

The purpose of this activity is to use a diffraction grating spectrometer to identify various light sources by observing their spectra and recognizing the chemical composition of the sun.

Part 1: FUNCTION OF THE DIFFRACTION GRATING

A diffraction grating is a device that takes light from a source and allows an observer to see what colors are mixed together to produce the color seen by the eye. Your diffractions grating is a hologram that produces a very bright spectrum of a source.

1. Carefully hold a slide of diffraction grating by the paper edges; never touch the plastic film in the center. Hold the diffraction grating next to your dominant eye (close the other eye). You will see streaks of color coming from every light and brightly illuminated object in the room. As the disk rotates, you should see the streaks of color rotate.

2. Look at an **incandescent** light bulb through the grating disk. Rotate the disk so that the spectrum of the light is oriented to the left and right (not vertical). Describe and draw what you see using the instructions below.

   A) Written Observations: Answer the questions below on a sheet of notebook paper.
   1. Describe what colors do you see?
   2. What color is closest to the bulb?
   3. Describe the light around the bulb. Are there colors on both sides of the bulb?
   4. Describe what you see when you rotate the disk.

   B) Drawing:
   1. Using colored pencils, draw what you see when you look through the diffraction grating.
   2. Your drawing must be on a half sheet of cardstock or heavy white paper (not construction paper).
   3. Draw and LABEL one light fixture and everything you see around one light fixture.
   4. Both this drawing and the drawing of the fluorescent light, should be labeled and mounted together onto one standard single sheet of construction paper. Label your drawings in black ink.

3. Look at a **fluorescent** light bulb through the grating disk. Rotate the disk so that the spectrum of the light is oriented to the left and right (not vertical). Describe and draw what you see using the instructions below.

   A) Written Observations: Answer the questions below on a sheet of notebook paper.
   1. Describe what colors do you see?
   2. What color is closest to the bulb?
   3. Describe the light around the bulb. Are there colors on both sides of the bulb?
   4. Describe what you see when you rotate the disk.

   B) Drawing:
   1. Using colored pencils, draw what you see when you look through the diffraction grating.
   2. Your drawing must be on a half sheet of cardstock or heavy white paper (not construction paper).
   3. Draw and LABEL one light fixture and everything you see around one light fixture.
   4. Both this drawing and the drawing of the incandescent light should be labeled and mounted together onto one standard single sheet of construction paper. Label your drawings in black ink.

What you SHOULD have seen with your diffraction grating….

The light bulb should produce a continuous like of color from red- orange-yellow-green-blue-violet coming out from the bulb with violet being the color closest to the bulb. This is the SPECTRUM of the light. The width of the line of color should appear as wide as the source of light. This is a CONTINUOUS spectrum blending from Red, Orange, Yellow, Green, Blue to Violet (ROYGBV). Any heated solid will produce this kind of spectrum.

The fluorescent bulb will also produce a spectrum, as wide as the fluorescent bulb, BUT you should also see images of the lamp in the yellow, green and violet parts of the spectrum. The continuous spectrum is caused by the fluorescent salt coating on the inside of the tube. The bright images of the lamp are specific colors produced by the gas inside the tube. (The gas is mercury vapor.)

USE THE SPACE BELOW FOR SCRATCH DRAWINGS:

Part 2: THE SPECTROMETER

A spectrometer allows you to view a light source through a thin slit. Instead of an entire spectrum, you will see an image of the slit located at its position in the spectrum. The spectrometer also has a scale so that specific numbers for wavelength can be assigned to specific colors. **Be sure and read the wavelength (nm) measurements on the bottom of the scale.** Note that the numbers on the scale are written backwards!

MATERIALS

1 spectrometer

1 fluorescent light AND 1 incandescent light bulb (bulb with a glowing filament)

Colored pencils AND heavy white paper/cardstock

PROCEDURE

1. Turn on a **fluorescent light** and look at the light through the spectrometer. Be careful to aim the slit (on the right side of the spectrometer) at the light bulb **BUT** look straight ahead at the spectrum on the scale. The spectrum from the fluorescent light should include several bright vertical "lines". These are images of the slit.

   Common fluorescent lights will have the mercury emission lines superimposed on a continuous spectrum. The green line of mercury occurs at 546 nm. To calibrate your spectrometer, check that you see a vertical green line at 546 nm. If you do not, take your spectrometer to your teacher to be adjusted.

2. Turn on an **incandescent light bulb** and look at the bulb through the spectrometer. Be careful to aim the slit (on the right side of the spectrometer) at the light bulb and look straight ahead at the spectrum on the scale. You should see a continuous spectrum of colors from red through violet. Mark on the scale below, Figure 1, the colors you see where you see them. Use colored pencils to shade in the observed colors.

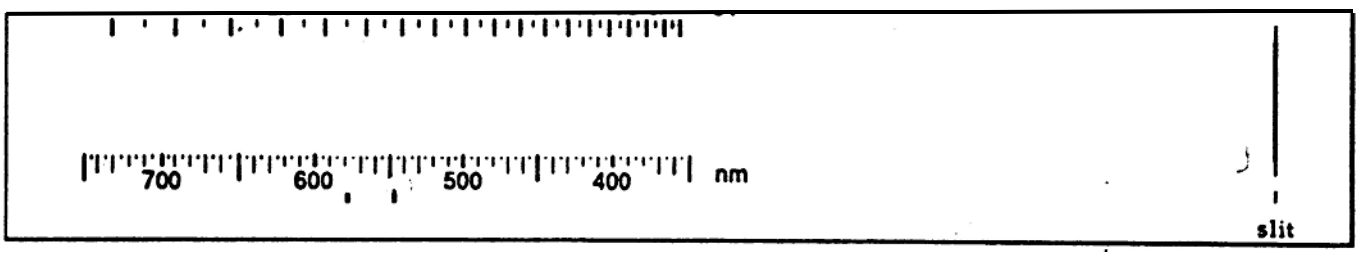

Figure 1

3. Read the number on the scale corresponding to the light farthest to the right that you can see and the number corresponding to the light farthest to the left that you can see.

   a). The observed spectrum extends from ________nm to _________nm.

   b). The colors at these places on the scale are: ___________and ________.

4. Now look at a **fluorescent light** through the spectrometer.

   a). <u>Describe</u> the spectrum you see. Is it different from the spectrum that you observed in Step 1?

5. Record the ends of the spectrum. The colored spectrum extends from ___________nm to ___________nm.

   Draw the bright vertical lines from the fluorescent light on the scale below, Figure 2.

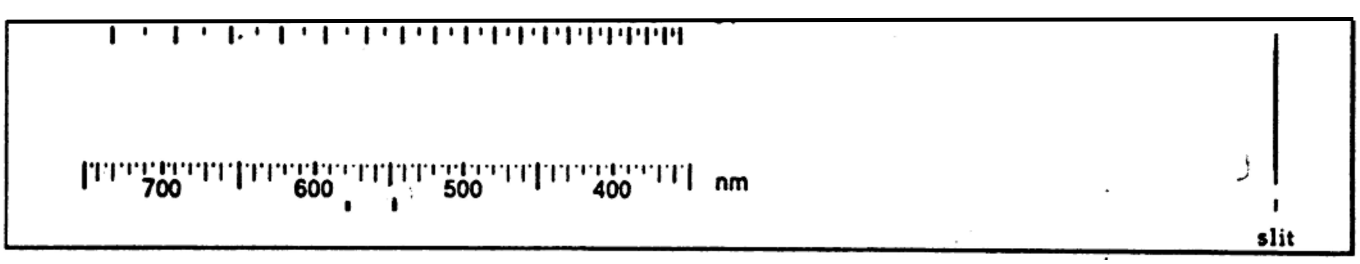

Figure 2

6. Read the positions of the bright lines on the scale. Record the color and position of the lines (in nm) in Table 1.

Color	Position (nm)

Table 1

7. Point the slit of your spectrometer at a VERY white surface that has a fluorescent light shining on it, such as a white poster, white shirt, etc. Record the positions of any bright lines that you see in Table 2.

   a) Compare the results of Steps 6 and 7. Was the spectrum that you saw from the fluorescent light similar to or different from the spectrum you saw when you looked at the white surface? Describe any similarities or differences.

Color	Position (nm)

Table 2

   b) Why do you think the spectra were similar or different?

8. Compare Fraunhofer absorption lines you see from a solar spectrum with those listed in Table 4 on the next page. Record the elements you conclude are present in the Sun in the table below.

	Color	**Position (nm)**	**Element**
C			
D			
E			
b			
F			
G			

Do you think that these are all the elements that are in the Sun? Why or why not?

9. Take your spectrometer outside (or look through a window from a darkened room) and point the slit toward the bright sky near the Sun. DO NOT LOOK DIRECTLY AT THE SUN!! IT CAN DAMAGE YOUR EYES!!

   You should see a spectrum of all colors with narrow, dark "shadow lines" superimposed. Measure the ends of the spectrum.

   a) The spectrum extends from

      ______________ nm to _______________ nm.

   b) Now read as closely as you can the positions of the any dark lines that you see. Record the color where you see the line and also the position of the line in Table 3. Which element(s) did you see on the Sun?

Color	Position (nm)

Table 3

10. Point the spectrometer slit at a bright white car – get as close as possible.

    a) Describe the spectrum that you see. How does the spectrum compare to the spectrum of the Sun?

    b) Why do you think this spectrum appears the way it does?

Table 4

ABSORPTION LINES IN THE SUN
(from the CRC *Handbook of Chemistry and Physics*)

Due to	Wavelength (nm)	Due to	Wavelength (nm)
Iron	372.8	Iron	516.8
Iron	382.0	Magnesium	516.7
Calcium	393.4	Magnesium	517.3
Calcium	396.8	Magnesium	518.4
Hydrogen	410.2	Iron	527.0
Calcium	422.7	Sodium	589.0
Iron	430.8	Sodium	590.0
Calcium		Hydrogen	656.3
Hydrogen	434.0	Oxygen	759.4
Hydrogen	486.1	Oxygen	762.1