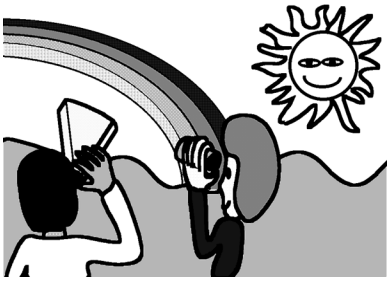
Spectroscopes

Elementary Version

In this activity, students build simple spectroscopes with which they can quantitatively analyze emission spectra of elements and compounds.



Objectives

The elementary version is best used with younger classes (grades 2-6), while the advanced version is most appropriate for older classes (grades 6-9). In this activity, students will be able to:

1. Build a spectroscope.
2. Record the spectrum lines in emission spectra of elements.
3. Distinguish elements and compounds by examining their emission spectra.

Materials

For each Student

- 1 square of diffraction grating (1")
- 1 cardboard tube, about 2" dia. x 4" long
- 2 railroad board squares, about 2-1/2" on a side
- 1 roll of clear tape
- 1 box of crayons containing red, orange, yellow, green, blue, violet
- 1 spectra worksheet (master on page 4)
- 1 scissors
- 1 pencil

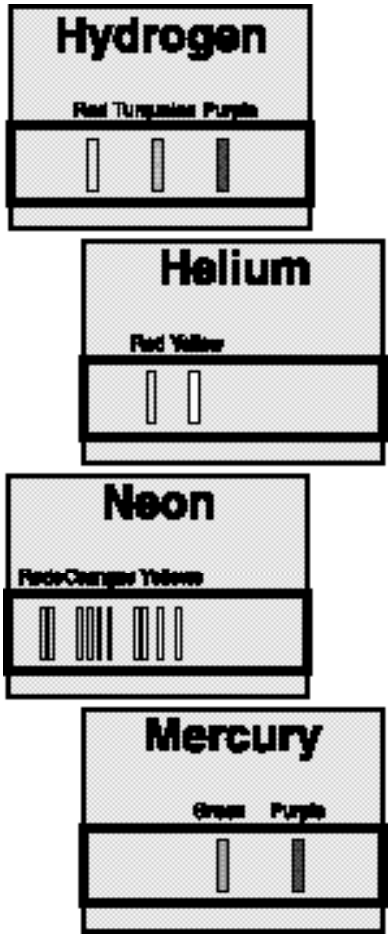
For the Class

- 1 Light bulb (ideally, tubular, unfrosted) & socket

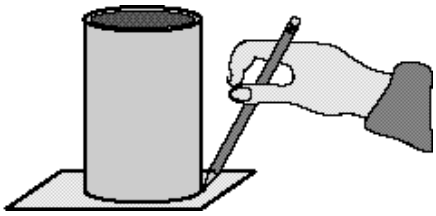
Optional

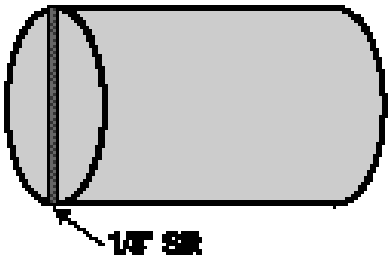
- *1 Spectrum tube power supply
- *1 Spectrum tube of each of the following gases — Hydrogen, Mercury, Helium, Water, Neon.

  Even if you don't have access to spectrum tubes and power supply, this activity can be done by having your students construct their spectroscopes, observe various light sources, and compare them with prepared posters of spectra of these elements as shown in the drawings on the right.



* See Materials sections of *Colors from Space* script for sources.





Before Class

1. Drill or punch a 3/4" hole in the center of half the railroad board squares. Drilling is most neatly accomplished with a drilling jig or by stacking the squares all together and sandwiching them between two pieces of scrap wood.
2. Gather all other supplies. For each student, make a copy of the worksheet.

In Class

1. One of the most important tools of the astronomer is a spectroscope which breaks light up into various colors. With spectroscopes, astronomers can tell what stars and comets are made of, and what's in a planet's atmosphere without having to go get samples. Getting samples, especially from stars, is impossible anyway. To see how a spectroscope works, each student will make his or her own simple spectroscope.
2. Making a spectroscope. (For each step, demonstrate before handing out materials for doing the step.)

   a. Using the cardboard tube as a guide, draw a circle outline on the railroad board square with the 3/4" hole in the center.

   b. With scissors, cut out the circle.

   c. Tape the diffraction grating square over the 3/4" hole, without covering the hole with tape. Caution your students to handle the diffraction grating square by the edges and not to get fingerprints on it.

   d. Tape the result of step 3 onto one end of the cardboard tube.

   Optional:

   e. Draw a circular outline of the tube on the second railroad board square, as in step (a), but without a hole in the center.

   f. Cut out the disc, then cut it in half.

   g. Tape the halves of the disc onto the end of the tube opposite the diffraction grating so that there is an approximate 1/8" slit between the halves. **Tape the half-discs so that they form a slit perpendicular to the direction of the color bands.**

      Turn on the bright white tubular unfrosted light bulb in the center of the room.

   What do you see when you look through your spectroscope? [Rainbow colors.]

      Make sure the students hold the diffraction grating ends close to their eyes. Check with each student to see that they do in fact see a rainbow of colors. Tell the students that the best way to see the colors is to turn the spectroscope until a big wide band of colors is seen spreading out to the sides.

   What color is closest to the light? [Purple.] What color is next to that? [Blue.] Next? [Green.] Next? [Yellow.] Next? [Orange.] And finally? [Red.]

      Tell your class that the colors of a rainbow are always in the order they see here. Suggest that they notice that next time they see a rainbow in the sky. Have the whole class repeat

together the colors of the rainbow as they see them in order from purple to red. Just for variety, have the whole class say the colors in order backwards (from red to purple).

A metal filament (usually tungsten) is giving off light inside the bulb. Since stars are made of gases, we are interested in seeing gases glow.

Every gas has a different "signature" of colors. This is how astronomers can tell what gases are in a star, comet, or planet atmosphere just by looking at the light through a spectroscope. You can see interesting spectra with your spectroscopes if you try looking at street lamps, neon store signs, and other bright light sources. Never look directly at the sun. [The sun displays a brilliant rainbow through the spectroscope but one must be careful to tilt the tube to one side and look only at the side of the tube farthest from the sun so that one is not looking directly at the sun through the end of the tube.] A safe way to observe the spectrum from the sun is to allow the sunlight to shine through the spectroscope and onto a piece of white paper or cardboard. You can observe an excellent spectrum right on the paper without having to look directly toward the sun.

Optional: Show the Spectrum Tube (Hydrogen)

In that tube is a gas called hydrogen, commonly found in stars. The tube can be made to glow by using the 10,000 volt light bulb socket (power supply). Hold your spectroscopes so that the colors spread sideways.

Turn the bright white light back on for them to readjust how they are holding their spectroscopes. Then turn the white light off and turn the hydrogen tube on.

How is this light different from the white light? [There are only certain thin lines of color.] What is the brightest color line? [Red.] What are the two next brightest color lines? [Turquoise and purple.]

Now hand out crayons and worksheets and have your students color what they see as the spectrum of hydrogen. Tell them how to spell hydrogen in the line next to "ELEMENT 1." Show the helium, neon, and mercury spectrum tubes and in each case, ask what the most prominent lines are and have your students color them

Homework assignment: use your spectroscope, crayons and paper to record the spectra of (1) a streetlight, (2) a restaurant sign, (3) a fluorescent light.

Can you identify the elements in the spectra you have drawn?

Drawing Spectra