Name _____ Date _____ Class _____

LAB 20 STUDENT WORKSHEET

DISCOVERY LAB

# *The Chemical Side of Light*

How do scientists know what elements make up the outer layers of the sun? After all, they can't just scoop up a bucketful of sun and bring it back to the laboratories on Earth for analysis. There must be some indirect way of determining the composition of the sun's outer layers. Scientists can tell what elements make up the outer layers of the sun by looking at sunlight through a device called a spectroscope. Like a prism, a spectroscope breaks up light into different wavelengths.

In fact, every element has its own "light fingerprint," which means that each element gives off distinctively colored bands of light! Shortly, you'll have a chance to correlate bands of light with the elements because Agent Spectra is about to send you a secret message made of light! To help you crack the code, Agent Spectra sent you the decoder card shown at right. Now all you need to do is construct a spectroscope and wait for the light signals. As soon as you identify the elements, you will read and interpret Agent Spectra's secret message!

Decoder Card

| Substance | Code |
|---|---|
| Na | for want of a |
| K | the |
| Hg | was lost |
| Ne | horse |
| Sr | nail |
| Cu | shoe |
| H + C | rider |

**MATERIALS**

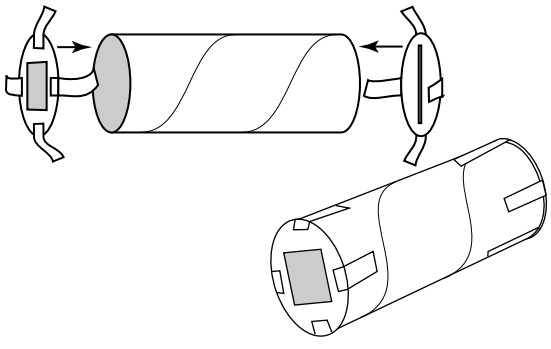
- cardboard tube
- index card
- scissors
- metric ruler
- diffraction grating
- masking tape
- set of crayons or colored pencils
- light source

## Objective

Determine the chemical composition of various light sources, and crack the code!

## Construct a Spectroscope

1. Trace two circles onto the card using the end of the tube.
2. Cut the two circles slightly larger than the tube's diameter.
3. Mark a 2 × 2 cm square in the center of one circle.
4. Cut the square from the circle so you have a square hole.
5. Tape the diffraction grating over the hole.
6. Tape the circle with the diffraction grating over one opening of the cardboard tube so that light must pass through the grating to enter the tube.
7. Bring the other circle to your teacher, who will cut a thin slit in its center.
8. Place the circle with the slit against the open end of the tube. Hold the circle in place as you look at a light source through the other end of the spectroscope.



9. The spectrum should appear on one side of the slit. Rotate the slit to make the spectrum as wide and as focused as possible. Tape the circle to the end of the tube in this position. This device is called a spectroscope.

10. A reference chart is on page 104. When you view each part of the signal, you will compare what you see in the spectroscope with the colored bands in the chart. Color your chart first to make identifying the spectra easier. Using crayons or colored pencils, color the red band as indicated on the chart. Follow the dotted lines, and color the rest of the bands so that each section corresponds with the band above it. Color this chart carefully and accurately so that you can crack Agent Spectra's code!

## Seeing Chemicals in a New Light

11. With the classroom lights off, view a light source through the spectroscope. Look quickly. Some spectra last only a few seconds.

12. Match the bands in the spectrum with the spectra you colored on your chart, and identify the chemical composition of the light source. Write the name of the substance and the corresponding phrase in the table below.

13. Repeat steps 11–12 for each light source.

### Decoding the Message

| Sequence | Substance | Word or phrase |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

14. Write out the complete message sent by Agent Spectra.

_____

_____

_____

Critical Thinking

**15.** What do you think the spectrum of a mixture of copper and potassium would look like?

**16.** Explain the message, and discuss how it could apply to the development of the periodic table.

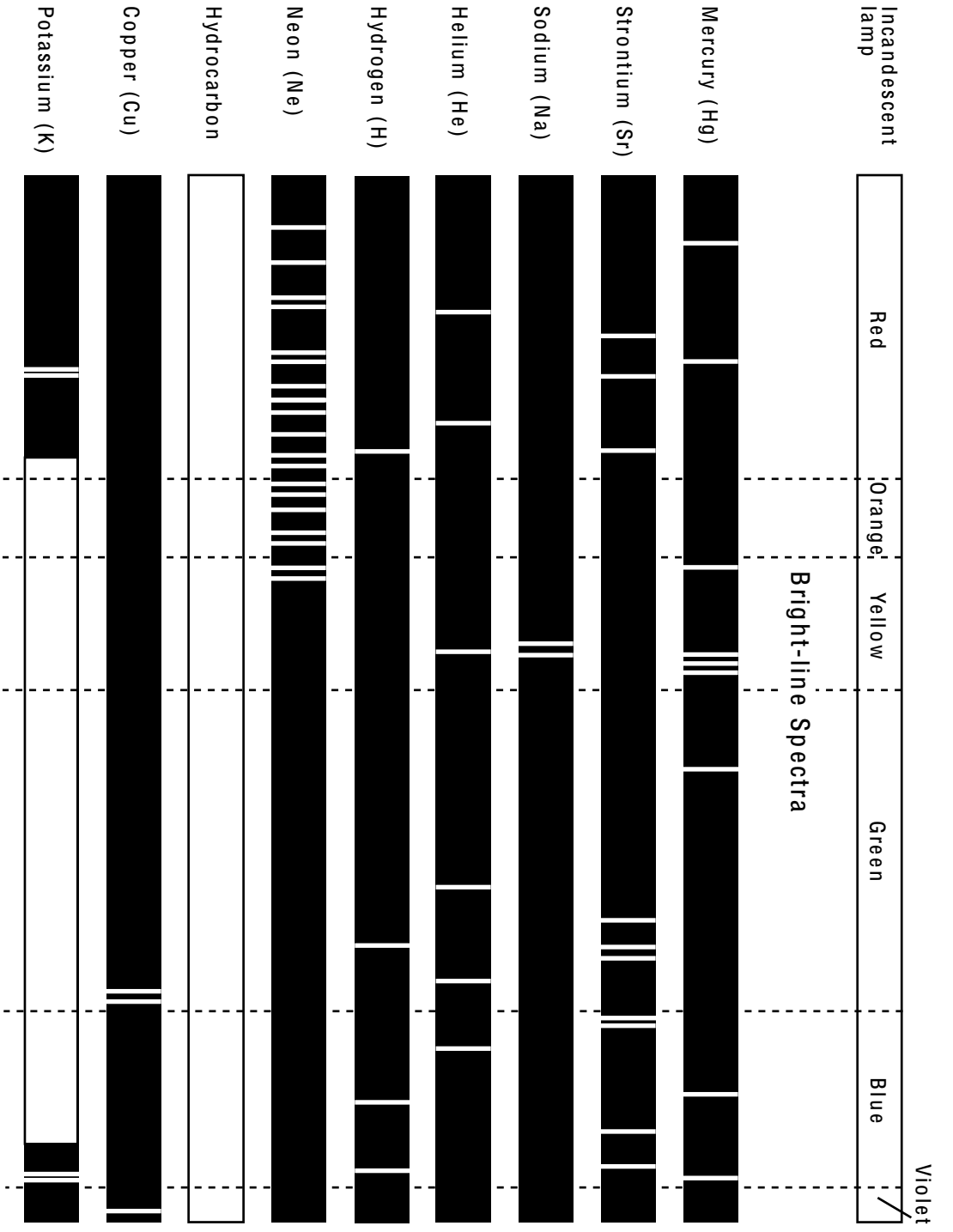


## *Going Further*

Use your spectroscope to determine the chemical composition of the sun. **Do not look directly at the sun through the spectroscope.** Write down some of the properties of the identified elements. Do the properties help you explain why the sun radiates thermal energy and light?

Name _____ Date _____ Class _____

## The Chemical Side of Light, continued



LAB 20 TEACHER'S PREPARATORY GUIDE

DISCOVERY LAB

# The Chemical Side of Light

## Purpose

Students construct a spectroscope to determine the chemical composition of various light sources.

## Time Required

Two 45-minute class periods—one to construct the spectroscope and one to receive and decipher the message

## Lab Ratings

EASY → HARD

TEACHER PREP

STUDENT SET-UP

CONCEPT LEVEL

CLEAN UP

## Advance Preparation

As instructor, you will act as Agent Spectra. Choose a message to send to the class. Below is a list of possible messages along with the chemicals required to send them. They are listed in the order to be transmitted. The quotations are from *Poor Richard's Almanac*, written by Benjamin Franklin. As you transmit each part of your message, students will determine the identity of the chemical by comparing the spectra they see with the spectra on their colored chart. If you would like students to see more spectra, transmit more than one code sequence.

For want of a nail, the shoe was lost.
Sodium, strontium, potassium, copper, mercury

For want of a shoe, the horse was lost.
Sodium, copper, potassium, neon, mercury

For want of a horse, the rider was lost.
Sodium, neon, potassium, hydrocarbon, mercury

## Gather the Materials

Ask students to bring empty toilet-paper tubes to class. The materials in the table above right and on page 100 supplement the student materials. The materials below are required to transmit all of the messages. Each of the materials should be available for less than $10. Purchase the chemicals from a scientific supply house.

You may wish to construct a spectroscope in advance to use as a model. To save time, you may order spectroscopes for less than $10 from a scientific supply house.

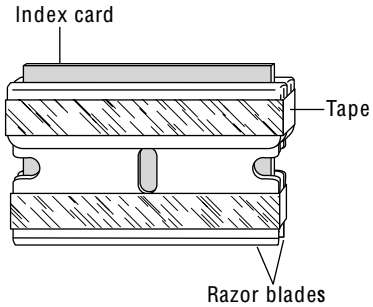
### ADDITIONAL MATERIALS

- Bunsen burner
- metal spoon
- gas sparker
- electrical outlet

## Spectroscope Construction

Holographic diffraction grating works best for this activity. You may substitute a prism, but the diffraction grating yields better results. Most scientific supply houses sell diffraction grating in sheets or rolls. Cut the grating into 2.5 × 2.5 cm squares.

Read steps 1–7 in the student worksheet. The blade of a craft knife is too thick to properly cut the slit for the spectroscope. To ensure a properly shaped slit, sandwich the index card between the dull sides of the razor blades and tape the three layers together. Use the razor assembly to cut a rectangular slit in the center of each student's circle.




***continued...***

CLASSROOM TESTED & APPROVED

**Dennis Hanson**
Big Bear Middle School
Big Bear Lake, California

**Safety Information**

Wear protective gloves and safety goggles when handling chemicals. Be sure to put on a pair of oven mitts before placing the knife in the flame. Students should use scissors and sharp objects with care.

**Teaching Strategies**

This activity works best when students work in pairs. Begin by asking students how we can identify different chemicals (smell, color, etc.). Tell them that in this activity they will identify chemicals by the emitted light spectra. When the students have cut out their circles, use the razor assembly to cut a 2 cm slit in the middle of each circle. Carefully punch the paper out of the slit so that you have an opening, as shown above.

Place the materials on your workspace in the order in which you will use them. As you send each part of your message, students will determine the identity of the chemical by comparing the sharp spectral lines they see in their spectroscope with the spectra on their color chart. For students to clearly see the spectra without flame interference, they should focus on the flame above the spoon. Listed below are the steps you should take for each source. Be sure to turn off the lights before students view the spectra.

For help evaluating this lab, see the Rubric for Performance Assessment and the Self-Evaluation of Learning Skills in the *Assessment Checklists & Rubrics*. These resources are also available in the *One-Stop Planner CD-ROM*.

## Procedure for Spectra Production

| | Sodium | Potassium | Mercury | Neon | Strontium | Copper | Hydrocarbon |
|---|---|---|---|---|---|---|---|
| **Materials (per class)** | 5 g of table salt | 5 g of potassium chloride (salt substitute) | fluorescent or sunlamp bulb | GE bulb (NE-34) or neon circuit tester | 5 g of strontium chloride | 5 g of copper sulfate | none |
| **Steps** | Dissolve in water in a spoon. Heat over a Bunsen burner. | Dissolve in water in a spoon. Heat over a Bunsen burner. | Screw the bulb into a socket. Turn on the light. | Screw the bulb into a socket; or plug circuit tester into an outlet. Turn on. | Dissolve in water in a spoon. Heat over a Bunsen burner. | Dissolve in water in a spoon. Heat over a Bunsen burner. | Light the Bunsen burner. |
| **Results** | yellow lines | 2 red lines on one side and 2 blue lines on the other | yellow; perhaps blue, indigo, and orange lines | yellow, orange, red, green, and blue lines | red lines | green lines | blue and green lines |
| **Chemical disposal** | Wash down the drain. | Wash down the drain. | none | none | Wash down the drain. | Wash down the drain. | none |

Name _____ Date _____ Class _____

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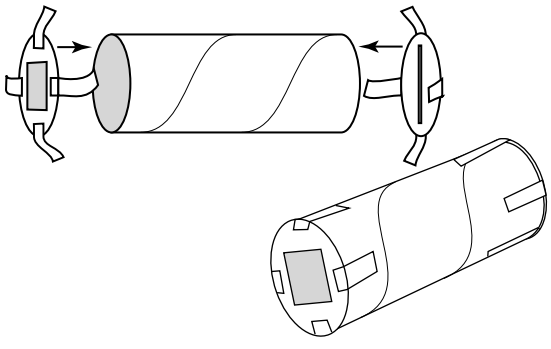

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Sample answer:

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| 3 | K | the |
| 4 | Ne | horse |
| 5 | Hg | was lost |

14. Write out the complete message sent by Agent Spectra.

Sample answer: For want of a shoe, the horse was lost.

Critical Thinking

**15.** What do you think the spectrum of a mixture of copper and potassium would look like?

I think that it would be like a combination of the spectra of copper and potassium. There would be green lines for the copper and red and blue lines for the potassium.

**16.** Explain the message, and discuss how it could apply to the development of the periodic table.

Sample answer: Disregarding details could be costly later. Scientists would have never figured out how elements interact with each other to form molecules if they had disregarded similar characteristics such as charge, number of electrons, and number of energy levels.



**Answer to Going Further:**

Distinguish between bright line spectra and dark line spectra. The spectra that students observed from the various light sources are called bright-line spectra. Because the sun's outer atmosphere absorbs some wavelengths of the sun's continuous spectrum, dark lines appear where the bright lines would have been. This is why we call the spectra that we see from the sun dark-line spectra. Students will see a continuous spectrum with thin, dark bands in several regions. They should also discover that the outer layer of the sun is composed mostly of hydrogen and helium.

## *Going Further*

Use your spectroscope to determine the chemical composition of the sun. **Do not look directly at the sun through the spectroscope.** Write down some of the properties of the identified elements. Do the properties help you explain why the sun radiates thermal energy and light?

Name _____ Date _____ Class _____

## The Chemical Side of Light, continued