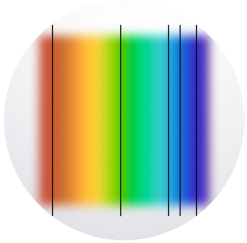

Diffraction Unit, Lesson 4; Missing Colors

Absorption Spectra

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Published by *K20 Center*

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Grade Level	9th – 12th Grade	**Duration**	2-3 days
Subject	Science		
Course	Physics		

Essential Question

How is light absorbed by substances? How are absorption spectra used to identify stars and the elements that make them up?

Summary

In this unit, students will learn that electrons in atoms and molecules absorb visible light. When light passes through various media and then through a diffraction gradient, it produces absorbance spectra. The produced absorption spectra are unique to the elements that interact with the light. These spectra can be used to identify elements and objects, including celestial objects. Students will perform two investigations into how various media absorb and transmit light and complete two guided inquiry model group activities.

Snapshot

Engage

Groups of students investigate how colored light is absorbed and transmitted through mediums of different colors.

Explore

Groups of students explore the topic by passing white light through various colored solutions and measuring the spectra produced by each solution.

Explain

Groups of students complete a guided inquiry model demonstrating how the electrons in atoms absorb light while transitioning between shells and how the absorbed light produces absorption spectra.

Extend

Groups of students complete a different guided inquiry model demonstrating how absorption spectra produced by celestial objects provide evidence of their compositional elements and are used to identify the objects.

Evaluate

Students answer the essential questions using the “What Did I Learn Today?” instructional strategy.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD304: Determine how the values of variables change as the value of another variable changes in a simple data presentation
IOD403: Translate information into a table, graph, or diagram
IOD404: Perform a simple interpolation or simple extrapolation using data in a table or graph
SIN201: Find basic information in text that describes a simple experiment
SIN301: Understand the methods used in a simple experiment
EMI301: Identify implications in a model
EMI401: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text
EMI502: Determine whether presented information, or new information, supports or contradicts a simple hypothesis or conclusion, and why
EMI505: Determine which experimental results or models support or contradict a hypothesis, prediction, or conclusion

Oklahoma Academic Standards (Physical Science)

CH.PS4.3 : Develop an argument for how scientific evidence supports the explanation that electromagnetic radiation can be described either by the wave model or the particle model, and in some situations one model is more useful than the other.

Oklahoma Academic Standards (Physical Science)

PS.PS2: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
PS.PS1.1.1: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
PS.PS1.1.2: The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
PS.PS4.1 : Use mathematical representations to explain both qualitative and quantitative relationships among frequency, wavelength, and speed of waves traveling in various media.
PS.PS4.1.1: The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

Attachments

- Elevated Electrons—Missing Colors - Spanish.docx
- Elevated Electrons—Missing Colors - Spanish.pdf
- Elevated Electrons—Missing Colors.docx
- Elevated Electrons—Missing Colors.pdf
- Gummed Up Photons—Missing Colors - Spanish.docx
- Gummed Up Photons—Missing Colors - Spanish.pdf
- Gummed Up Photons—Missing Colors.docx
- Gummed Up Photons—Missing Colors.pdf
- Lesson Slides—Missing Colors.pptx
- Star Codes—Missing Colors - Spanish.docx
- Star Codes—Missing Colors - Spanish.pdf
- Star Codes—Missing Colors.docx
- Star Codes—Missing Colors.pdf
- What is Missing—Missing Colors - Spanish.docx
- What is Missing—Missing Colors - Spanish.pdf
- What is Missing—Missing Colors.docx
- What is Missing—Missing Colors.pdf

Materials

- Lesson Slides (attached)
- Gummed Up Photons handout (attached; one per student)
- Elevated Electrons handout (attached; one per group; print two-sided, not stapled)
- What is Missing handout (attached; one per student)
- Star Code handout (attached; one per group; print one-sided)
- 3 Gummy Bears (white, red and green; one set per group)
- Colored lights (laser or LED; red and green; one per group or shared between groups)
- Notecards (one per group)
- C-spectra® slide 2” by 2” (one per student or per group)
- 5 test tubes (one set per group)
- Test tube rack (one per group)
- Cell phone camera light or other bright light source (one per group)
- Food dye (red, green, blue and yellow; one per class)
- Water (enough for each group to have 25 mL)
- 30 cm ruler (one per group)
- Set of colored pencils (one per group of three)
- Notebook paper
- Pencils

Engage

Teacher's Note: Alternative Activity

If you are unable to have students participate in the investigation, unhide **slide 11** to show the Properties of Light, Gummy Bears, Biggest Misconceptions Kids Have video of the investigation. Continue to have students make predictions and participate in the I Notice, I Wonder instructional strategy.

Use the attached **Lesson Slides** to present the lesson.

Display **slides 1-4** to introduce the essential questions and learning objectives.

Put students in groups of four to five. Explain that students will shine red, white, and green lights through red, green and white gummy bears. They will make observations about the different colored lights as they shine through each of the three gummy bears.

Display **slide 5** and inform them that they will perform an investigation called Gummed Up Photons using gummy bears and lasers. Pass out the attached **Gummed Up Photons** handout to each student.

Display **slide 6** and have students discuss in their group what they think will happen when each light is shined through the different color gummy bears. Have students record their predictions in their handout.

Display **slide 7** and introduce the I Notice, I Wonder instructional strategy to the class. Inform students that they will write their responses on the handout.

Display **slide 8** and emphasize the safety procedures students need to follow for the lasers.

Display **slide 9** and pass out or have students collect the materials needed for the investigation.

Teacher's Note: Material Guidance

If there are not enough light materials for each group, consider a teacher demonstration. Also, consider having groups share the materials and take turns with the lasers/LED lights.

Move to **slide 10** and explain to the class that they will set three gummy bears on a table and stand an index card upright behind them. Then, they will shine one of the three lights through each of the gummy bears and notice the colors that shine through. Have students refer to the detailed instruction on their handout. While conducting the investigation, have students discuss with their group the following question:

Is there a relationship between the color of light, the color of the medium and the absorbance of light?

They will repeat the procedures with each light for all three gummy bears.

After completing the investigation, discuss as a class what the students observed, if their predictions were correct, and any questions they still have. Collect all supplies or have students place materials in a designated location.

Explore

Put students in new groups of two or three. Inform students they will complete another investigation called "What is Missing?". Students will now use a white light and pass it through a clear, red, blue, green, and yellow solution.

Display **slide 12** and explain the color wheel and complementary colors. Tell students that it will be helpful to use the idea of complimentary colors when making predictions about light absorbance.

Transition to **slide 13** and tell students to use their observations from the "Gummed Up Photons" activity to predict how the spectrum will change when each colored water is held in front of the light. Have students record their responses in their notebooks or on a piece of paper.

Display **slide 14** and pass out or have students collect the materials needed for the investigation. Pass out the attached **What is Missing?** handout to each group.

Teacher's Note: Material Guidance

You can use one container of food coloring for each color. Have students pass them around to share or transfer the food coloring to separate containers.

Display **slide 15**. Explain to the students that they will view the light through a 2x2" piece of spectra plastic. They will hold test tubes with clear, red, blue, green and yellow colored water in front of the light source while viewing the spectrum through the spectra plastic. They need to focus on the colors they see, but also on the colors that are missing. Remind students that white light contains all colors of the spectrum.

Have students complete the following steps to prepare their materials:

1. Prepare five test tubes with about 5 ml of water in each.
2. Place the tubes in a rack.
3. Add one drop of red, green, blue and yellow food dye to four separate test tubes.

Have students complete the following procedure (more detailed procedures on the students' handout):

1. Prop up their light source.
2. Hold the plastic slide between the light source and a wall so they can see a continuous spectrum.
3. While focusing on the spectrum, have a group member move the test tube with no dye in front of the light source.
4. Record their observations in their notebook.

Repeat the steps for each of the four colored solutions. (Note which colors of light are being absorbed by the different dyes).

Display **slide 16**. As students watch the following video pause the video at the times below to allow students to make predictions as to what color light will be shown or missing. Show the Absorption spectra with light of select metal ions video to the class pausing at:

- 1:20 to make predictions about the light absorbed by iron solution
- 2:15 to make predictions about the light absorbed by copper solution
- 3:30 to make predictions about the light absorbed by permanganate solution
- 4:50 to make predictions about the light absorbed by iron solution

Embedded video
https://youtube.com/watch?v=Jhb_RSiWnhk

Before having students make predictions, share **slide 17** with the students and explain that each colored solution represents a different ion. Toggle back and forth from the video and slide 17 to help students make predictions at the designated stopping points.

This is a good place to end day 1.

Explain

Begin day 2 here.

Teacher's Note: Changing Groups

Change up the groups students are working with to allow students to learn from different peers and experience new ideas.

Display **slide 18.** Have students get in groups of three. Give each group the **Elevated Electrons** handout. Have students in each group take on a role as a reader, recorder, or reporter. The reader will read the text from pages 1 and 2 of the handout, the recorder is responsible for recording the answers from page 3 of the handout, and the reporter will share out with the group. Have the recorder write the answers down in a notebook or on a sheet of paper. Allow time for students to answer questions and record answers.

Teacher's Note

The **Elevated Electrons** handout refers to the **Electrons in Atoms** handout from Diffraction Lesson 2: Funky Flames.

When each group has completed the handout, ask for volunteer groups to share their answers to select questions. Go through each question as a class using **slides 18-19** to help explain answers.

- Slide 18 helps explain questions 8-9.
- Slide 19 helps explain questions 10-12.

This is a good stopping point for day 2.

Extend

Begin day 3 here.

Display **slide 20**. Have students stay in the same group, but have students switch to a new role as a reader, recorder or reporter. Give each group the **Star Codes** handout. The reader will read the text from page 1 of the handout, the recorder is responsible for recording the answers from page 2 of the handout, and the reporter will share out with the group. Have the recorder write the answers to the questions in a Science notebook or on a sheet of notebook paper. Allow time for students to answer questions and record answers.

Once all students have recorded their answers, have reporters from each group share select answers with the class. To save on time you could have each group answer one or two questions. Then share **slides 21-23** to help students grasp the concept of the solar spectrum providing evidence of the Sun's elemental composition.

Transition to **slide 24**. Share the Spectroscopy of the Stars video with the class. This video will review the emission of visible light by metals and how it is used to identify elements making up stars. This is a good time to reinforce the learning objectives of the lesson.

Embedded video
https://youtube.com/watch?v=n_KyYFYNvpI

Evaluate

Display **slide 25** and introduce the What Did I Learn Today? instructional strategy. On a sheet of paper, have students answer the two essential questions and add any additional information they have learned over the past few class periods.

- How is light absorbed by substances?
- How are absorption spectra used to identify stars and elements that make them up?

Collect students' responses to use as a formative assessment.

Resources

Diffraction Unit, Lesson 2: Funky flames. K20 LEARN | Diffraction Unit, Lesson 2: Funky Flames. (n.d.). https://learn.k20center.ou.edu/lesson/2439

K20 Center. (n.d.). I notice, I wonder. strategies. Retrieved from https://learn.k20center.ou.edu/strategy/180

K20 Center. (n.d.). What Did I Learn Today?. strategies. Retrieved from https://learn.k20center.ou.edu/strategy/169

MrGrodskiChemistry. (2013, December 10). *Absorption spectra with light source of selected metal ions.* [Video]. YouTube. https://www.youtube.com/watch?v=Jhb_RSiWnhk

Aurora Lipper. (2015, September 20). *Homeschool science experiment: Properties of light, Gummy Bears, biggest misconceptions kids have.* [Video]. YouTube. https://www.youtube.com/watch?v=lSRaJTzY0go

BBC. (2011, March 11). *Spectroscopy of stars - wonders of the universe: Stardust - BBC Two*. [Video]. YouTube. https://www.youtube.com/watch?v=n_KyYFYNvpI