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| **Unit: Spectra** |
|  **Stage 1 – Desired Results** |
| **Established Goals: Content Standard: Unifying Concepts and Processes - As a result of activities in grades k-12, all students should develop understanding and abilities aligned with the following concepts and processes:** Evidence, models, and explanation**Content Standard A: Science as Inquiry - As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry:** Identify questions and concepts that guide scientific investigations.**Content Standard B: Physical Science - As a result of their activities in grades 9-12, all students should develop an understanding of** Structure of atoms; Structure and properties of matter; Interactions of energy and matter**Content Standard E: Science and Technology - As a result of their activities in grades 9-12, all students should develop** Understandings about science and technology: Science advances with new technologies**Content Standard G: History and Nature of Science - As a result of their activities in grades 9-12, all students should develop understandings of** Science as a human endeavor - Individuals and teams have contributed to scientific enterprise; Nature of scientific knowledge - Scientific explanations must be consistent with experimental and observational evidence, make accurate predictions, logical, open to criticism; All scientific knowledge is subject to change as new evidence becomes available; Historical perspectives - Often changes in science occur as small modifications in existing knowledge; Some advances have important and long-lasting effects on science and society; Science explanations build on earlier knowledge |
| **Understandings:***Students will understand that …*A spectrum is light that has been separated.Spectrums are categorized into three groups – continuous, absorption and emission spectra.Continuous spectra is caused by thermal radiationEmission and absorption spectra are caused by electrons absorbing or releasing energy | **Essential Questions:****What information is hidden in light?****How do astronomers know what stars are made of?** |
| *Students will know …**How peak wavelength is related to temperature**Kirhhoff’s 3 laws of spectra**How the OBAFGKM scale is related to temperature of stars and colors of stars* | *Students will be able to …*Identify temperature by peak wavelengthIdentify continuous, absorption or emission spectraUse a spectroscope to view emission spectraIdentify elements in an object by its emission spectraClassify spectra using OBAFGKM |
|  **Stage 2 – Assessment Evidence** |
| **Performance Tasks:****Identify elements by emission spectra****Identify stars by OBAFGKM through spectra** | **Other Evidence:****Written test** |
|  **Stage 3 – Learning Plan****H hook I introduction C content P practice R revise E evaluate****BK Knowledge BC Comprehension BAp Application BAna Analysis BS Synthesis BE Evaluation**  |
| **Learning Activities:****1. Spectra eyeglasses & Christmas lights H, I BK****2. Blackbody Radiation PP talk C, P BK****3. Blackbody applets website & worksheet C, P BC BAp BAna****4. *Blackbody Radiation* worksheets P BAp BAna****5. *The Story of Spectra* PP talk C, P BK BAp BAna** **6. Stanford Solar Center Spectroscopes P, R, E BAp BAna BE****7. Spectra Stations P, R, E BAp BAna BE****8. Analyzing Spectra worksheets P, R, E BAp BAna BE****9. Harvard’s Computer PP Talk C BK BC****10. Star cards P R E BAna BS BE****11. Sloan Spectra P R E BAna BE****12. Red Shift C P R E BK BC Bap BAna BE****13. Written Test E BS BE** |

**1. Spectra eyeglasses & Christmas lights H, I**

Objective: Introduction to spectra

Activities: 1. Students will wear spectra eyeglasses and view white Christmas lights and then colored Christmas lights. Point out the lines of color and relate to glass prisms. Explain diffraction gratings (1000s of lines etched on plastic – bending light). Look at different lights.

2. Look at light bulbs of different colors (easier than Christmas lights – bigger)

Materials: spectra eyeglasses; Christmas light strands – white & colored; colored light bulbs & sockets

Big Idea: Prisms break up white light to show the hidden colored light

**2. Blackbody Radiation PP Talk C, P**

Objective: Blackbody radiation & peak wavelength

Activity: Whole class blackbody radiation PP talk

Materials: PP blackbody talk

Big Idea: Blackbodies have a characteristic graph. Their peak wavelength is related to the temperature of the object

**3. Blackbody Applets website & worksheet P**

Objective: Practice using Wein’s Law and the Luminosity relation to analyze light

Activities: 1. Students use applet to compare peak wavelengths of stars of different temperatures

Materials: Worksheet *Blackbody Applets*; computers & internet

Big Idea: Peak wavelength of blackbody radiation is related to the temperature of the star

**4. Blackbody Radiation worksheets P, R, E**

Objective: Practice using Wein’s Law and the Luminosity relation to analyze light

Activity: 1. Students will complete worksheets comparing blackbody radiation curves of objects with different temperatures.

2. Go over answers – assign a set of questions to each table

Materials: *Blackbody Radiation* worksheet

Big Idea: Peak wavelength is related to temperature; Star color is related to temperature; Star size & temperature is related to luminosity

**5. The Story of Spectra PP talk C, P, R**

Objective: Historical development of theory of spectra

Activities: 1. Whole class PP talk about spectra

2. Break in the middle of the talk – have students work on *Type of Spectra* worksheet. Go over answers

3. Demo of colored light – watch glasses of colored flame (element crystals & methanol) – put enough crystals on a dish with methanol. Methanol will burn but then the crystals will burn colored light

4. Return to PP, go over electrons role in absorbed or emitted light.

5. Have students go to <http://www.bigs.de/en/shop/anim/termsch01.swf> to figure out what difference between the lyman series, the Balmer series, the Paschen series and the Brackett series using worksheet and website

Materials: *Type of* Spectra worksheets; 6 watch glasses; methanol; boric acid, lithium, cupric, strontium, calcium, sodium; *Hydrogen Series* worksheet, computer & internet

Big Idea: 3 types of spectra; How each is created; Use of spectra for elemental identification; No relation of placement of absorption or emission lines to temperature of stars – it is the overall pattern that is important

**6. Stanford Solar Center Spectroscopes P, R, E**

Objective: Learning how to use a spectroscope

Activities: 1. Students will construct a spectroscope using the Stanford Solar Center spectroscope.

2. Have students practice using it on ceiling florescent lights and light bulb. Also can look at hallway lights.

3. *Using your spectroscope* worksheet – students will use their scope outside of school and record the spectra they see.

Materials: Stanford Solar Center spectroscope; scissors; glue; tape; light bulb & socket

Big Idea: Learning how to use a spectroscope

**7. Spectra Stations P, R, E**

Objective: Students will observe continuous, emission & absorption spectrum; Students will identify elements in spectra using known and unknown spectra; Students will look for patterns between absorption/emission spectra and temperature

Activities: 1. Students can move through the following stations at their own pace:

1. Flame tests – a simulation of Bunsen & Kirchhoff’s work; Students will use their spectroscope to get a sense of what Bunsen & Kirchhoff had to go through; Students will record the colors of specific elements and identify the mystery solution
2. Gas discharge tubes – students will record emission spectra on the *Blank Spectra* worksheet. Shine white lights shining on the cabinets to backlight the area so the scale inside the spectroscope can be seen
3. Glow slate – students will view absorption spectrum with the toy slate and a light bulb
4. Street side window – Students will look out the street side hall window at the sky to observe absorption lines in solar spectrum
5. Identifying elements in spectra – students will complete worksheets with unknown and known spectra

Materials: Flame tests – flame loop; solutions of elements; Bunsen burners; *Flame Tests* worksheet;

Gas discharge tubes – gas discharge lamps; *Blank Spectra* worksheet; white lights

Glow slate – toy slate; white light bulb & socket

Identifying elements in spectra – worksheets of known and unknown spectra (3)

Big Idea: Observation of continuous, emission & absorption spectra

**8. Analyzing Spectra Worksheets P, R, E**

Objective: A star’s peak wavelength is the only correlation to its temperature

Activities: Students will complete *Analyzing Spectra* worksheets. Go over the answers together

Materials: *Analyzing Spectra* worksheets

Big Idea: The placement of spectral lines is not correlated to a star’s temperature. Only peak wavelength is related to a star’s temperature (and color).

**9. Harvard’s Computers PP Talk C**

Objective: Historical development of spectral classification OBAFGKM

Activities: 1. Whole class PP talk about Harvard computers

2. In the middle of the talk, students try to sort spectra as Annie Jump Cannon did. They will compare their classification to Cannon’s.

3. Finish PP talk, covering Cannon’s and other Harvard’s computers life & contributions

Materials: PP notes *Harvard’s computers*; Spectra & grid set for each table;

Big Idea: Harvard computers were women who analyzed stellar images & spectra, who were paid poorly and not really allowed to advance; Spectra is classified by temperature and strength of elemental absorption lines

**10. Star Cards**

Objective: Star color is indicative of a star’s temperature

Activity: Give each table a set of star cards and students will look for confirmation of color with temperature

Materials: Star cards – a set for each table

Big Idea: Temperature of a star is correlated to its color

**11. Sloan Spectra**

Objective: To identify spectra by classification OBAFGKM, C, White drawf, Galaxy, Quasar, binary star, luminous Red Galaxy and nebula; Assessment

Activity: Give each student group a set of spectra. Put the groups on board and have groups sort spectra by what they are.

Materials: Spectra set for each group

Big Idea: Shape of spectral graph is related to temperature

**12. Red Shift**

Objective: To be able to determine red shift or blue shift from spectra

Activities: 1. View You tube video as introduction to red shift *What is a Redshift?* <http://www.youtube.com/watch?v=FhfnqboacV0>

2. View Beyond the Solar System video – Evidence: *What stars are made of* and *The speed of galaxies*

3. 3 Galaxies & Hydrogen spectra – students determine order of speed from earth

4. Genesis Search for Origins – *Doppler Effect* *Are you coming or going?* – Read through the Student reading sheet and then complete the problems on the Student reporting /data sheet

Materials: Youtube video *What is a Redshift* <http://www.youtube.com/watch?v=FhfnqboacV0> ; BTSS DVD; Worksheets from Genesis Search for Origins – *Doppler Effect Are you coming or going Student Reporting/Data Sheet* & *Student Text*

Big Idea: Objects moving away from Earth show redshift; Objects moving toward Earth show blueshift;

Objects moving faster show greater redshift

**13. Spectroscopy Questions**

Objective: Review - Practice questions

Activity: Students complete worksheet with questions about spectra concepts – practice for test

Materials: Worksheet *Spectroscopy Questions*

Big Idea: Review of spectral concepts

**14. Written Test**

Objective: Assessment

Activity: Students will take written test

Materials: Written test

Big Idea: Assessment