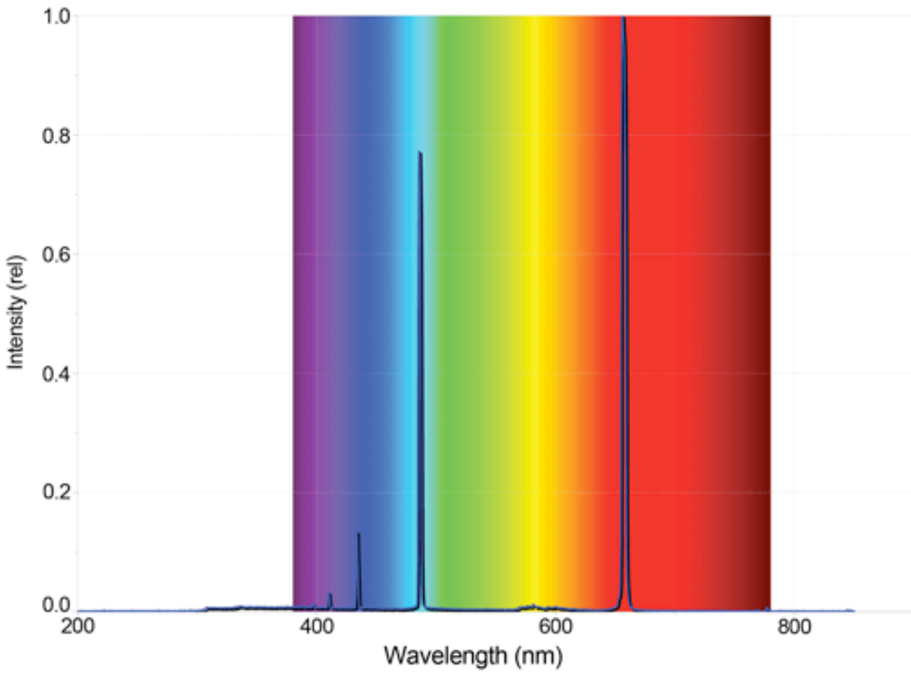
The Emission Specturm of Hydrogen gas



http://www.vernier.com/innovate/measure-gas-discharge-tube-emissions/

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RET Lesson Plan: The Emission Specturm of Hydrogen gas

Primary Subject Area: Chemistry

Grade Level: 10th

Overview:

Elements, when heated, release only certain wavelengths of light (**line spectrums)** rather than the entire continuous spectrum. Therefore, by observing which colors of light are released, we can identify which element we are observing.

To develop his planetary model of an atom, Bohr studied the line spectrum of hydrogen gas. When an electron absorbs a **quantum** of energy it leaps to a higher energy level and then releases that energy as a **photon** of light when it falls from this excited state back to ground state. We are going to observe this line specturm and calculate the wavelengths of light emitted by excited hydrogen gas. We will also use these wavelengths to calculate the energy of the photons emitted and their frequencies.

By the end of the unit students should be able to perform calculations relating wavelength, frequency, and energy, as well have have a good understanding of how these three variables relate and what colors of visibile light are associated with them. Students will connect this understanding to Bohr's model of the atom.

Approximate Duration: 2-3 class periods (60 minutes each)

MA Frameworks:

I. High School Chemistry Content Standards:

2.1 Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to modern theory.

II. High School Earth and Space Science Content Standards:

1.2 Describe the characteristics of electromagnetic radiation and give examples of its impact on life and Earth's systems.

III. Scientific Inquiry and Skills Standards:

SIS1. Make observations, raise questions, and formulate hypotheses.
SIS3. Analyze and interpret results of scientific investigations.

IV. Mathematical Skills

Represent data and relationships between and among variables in charts and graphs.
Use appropriate technology (e.g. graphing software) and other tools.
Use mathematical operations to analyze and interpret data results.
Construct and use tables and graphs to interpret data sets.
Solve simple algebraic expressions.
Measure with accuracy and precision.
Convert within a unit.
Use common prefixes such as *milli-, centi-,* and *kilo-*.
Use scientific notation where appropriate.
Determine the correct number of significant figures.
Determine percent error from experimental and accepted values.

Interdisciplinary Connections: physics, history

Lesson Objectives:

The students will be able to:

- Summarize activities using vocabulary associated with light and the electromagnetic spectrum correctly.
- Identify the emission spectrum of hydrogen gas.
- Calculate the wavelenths colors and frequencies of the emission spectrum of hydrogen gas.
- Explain the connection between the emission spectrum of hydrogen gas and the Bohr model of the atom.

Lesson Materials and Resources:

- Powerpoint presentation reviewing models of the atom and introducing light and the electromagnetic spectrum.
- Several different gas discharge tubes and power supplies.
- Hand held spectroscopes:

image from: http://chem.wisc.edu/deptfiles/genchem/lab/labdocs/modules/spectro/spectrodesc.htm

- A classroom with a window and an overhead light.
- Vernier probe software: Vernier Spectrometers, computers with Logger Pro 3 software installed, fiber Optic accessory, hydrogen gas discharge tube, dischare tube power supply.
- Ryberg Constant lab: http://www2.vernier.com/sample_labs/VSPEC-08-COMP-rydberg_constant.pdf
- Light CalculationsWorksheet (example available below) for practice with mathematics involved.
- Applet: http://phet.colorado.edu/en/simulation/hydrogen-atom

Technology Tools and Materials:

- Vernier probe software: Vernier Spectrometers, computers with Logger Pro 3 software installed, fiber Optic accessory, hydrogen gas discharge tube, dischare tube power supply.

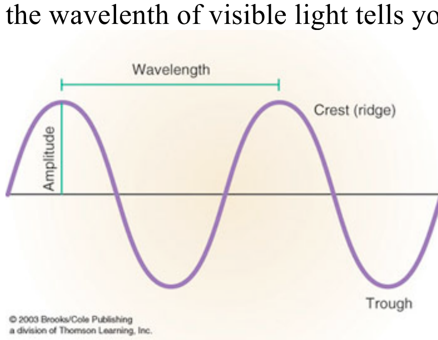
Background Information (prior knowledge):

Students should come into this unit with a strong understanding of the subatomic particles that make up an atom (protons, neutrons, and especially electrons, relative sizes and charge, etc.). Although the lesson begins with a quick review of the early models of the atoms, student should have learned the basics of the Bohr model before beginning this lesson (i.e. nucleus = protons + nuetrons, electrons 'orbiting' around, etc.).

Students should have strong algebraic skills (completed Algebra 1 at the least).

Students should have a basic understanding of element symbols, atomic number, atomic mass.

Useful Vocabulary:

New Vocabulary Word	Meaning
Electromagnetic Spectrum	All wavelengths of the radiation emitted from the sun.
Visible light	EM radiation with wavelengths between 400nm – 700nm. ROY G BIV
Wavelength	The distance from crest to crest of a wave. The wavelength indicates the type of EM radiation (ex. microwave, infrared, UV, visible). Knowing the wavelenth of visible light tells you the color the light. 
Amplitude	The height of the wave. Related to the intensity (strength) of the light.
Speed of light (c)	$2.99x10^{8}$ m/s All EM radiation travels at this speed.
Frequency	How many waves pass through a given point per second. Measured in Hertz ($1Hz= 1s^{-1}$).
Photon	A 'particle' of light. A photon has no mass, but carries a quantum of energy.
Quantum	An 'energy packet.'

Essential Questions to be answered (Grand Challenges):

How is the emission spectrum of Hydrogen gas explained by Bohr's model of the atom?

Misconceptions:

There are very few misconceptions, because students rarely come into chemistry with any knowledge of what an atom is at all – aside from just something small that looks kind of like the solar system. They do not usually know anything about the connection between light and electrons, and they know very little about how that model was derived.

- Electrons are so small we cannot observe them in any way in a classroom setting.

Lesson Procedures:

CLASS 1:

1. Set up different gas tubes around the room and turn out the lights so students walk in to what looks like a little light show. Introduce lesson by asking the essential question (i.e. 'how do these tubes, particulary the hydrogen gas tube, relate to our understanding of the atomic model?').
2. Ask the students to help you make a list of what they might need to know to understand this. Put this list on the whiteboard. Hopefully it will look something like this:

> What is light?
> What is in these tubes?
> Why are different tubes emitting different colors of light?
> What are the models of the atoms that we know?

3. Review the atomic models they have learned so far: Dalton's Billiard Ball, JJ Thomson's Plum Pudding, Rutherford's Gold Foil, Bohr's Planetary Model (see Powerpoint for images).
4. Hand out handheld spectroscopes. Have students look at white light and then a few different discharge tubes. What do they notice?
5. Lecture/discuss light and the electromagnetic spectrum with students (again see Powerpoint). If there is time have students break into groups of 3-4 and each investigate a type of electromagnetic radiation for 15 minutes – then present what they found informally to the class.
6. Discuss/do example problems relating the energy (E) of a photon, the wavelength (λ) if the light, the color of the light, and the frequency (ν) of the radiation.
7. HW: Practice problems relating the energy (E) of a photon, the wavelength (λ) if the light, the color of the light, and the frequency (ν) of the radiation. An example HW worksheet is at the end of this lesson.

CLASS 2:

8. Give students time to compare their work with a partner. Take questions / go over problems.
9. Review essential question. Review what we have learned so far: light, models of the atom (i.e address which of the things on the whiteboard list we have covered).
10. Perform Vernier Lab: The Ryberg Constant (http://www2.vernier.com/sample_labs/VSPEC-08-COMP-rydberg_constant.pdf) – this lab includes a prelab exercise the students should have to submit in teams before moving on to doing the lab itself.
11. At the end of the lab discuss with Powerpoint slides how what they did relates to the Bohr model.
12. As students finish the lab have them play around with the following applet to reinforce the knowledge they just gained from lab: http://phet.colorado.edu/en/simulation/hydrogen-atom
13. Have students each write a quick paragraph to hand in (or email) summarizing the lesson using at least 4 new vocabulary words.

Assessment Procedures:

Formal Assessments:

- The HW due at the beginning of class 2 should be graded.
- The pre-lab exercise at the beginning of the lab should be graded.
- The paragraphs written at the end of class 2 should be collected and graded.
- The lab data-analysis should be collected the day after the lab is performed and graded.
- All of the material in this lesson should appear on the unit exam at the end of the entire Atomic Models, Light, and Electrons Unit. (*this exam is not included as every teacher might have a different entire unit).

Informal Assessments:

- Every 'lecture' should be more of a discussion where the appropriate vocabulary is used by both teacher and students.

- Students presenting their information on the electromagnetic spectrum.
- At the beginning of class 2 the teacher should gain a strong idea of how well students are grasping the problems. If they are having trouble on calculations do more practice problems and lengthen the amount of time spent on class1 material before moving on to the Vernier Lab.

Accommodations/Modifications:

- Students who are not as strong in math can look at the several different gas discharge tubes and use colored pencils to draw the emission spectrum of each gas. Have students make hypothesis as to why each spectrum is different. Walk students through the hydrogen emission spectrum and Bohr's model of an atom rather than have them do the calculations.

Reproducible Materials:

- Light Calculations Worksheet (example included at end of this lesson)
- Vernier Lab: http://www2.vernier.com/sample_labs/VSPEC-08-COMP-rydberg_constant.pdf

Explorations and Extensions: There are several ways to extend this lesson.

Lesson Development Resources: *The following resources were drawn upon to design this lesson.*

1. *The Ryberg Constant Lab, 2010 Vernier Software & Technology*
2. *My fellow RET teachers at the NSF RET at BU 2012*

Reflections: *(to be filled in upon teaching this lesson)*

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Light Calculations Worksheet NAME:__________________________

Useful Information:

$E=hv$ $R = 2.18 \times 10^{-18} J$

$c=\lambda v$ $h = 6.63 \times 10^{-34} Js$

$E = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ $c = 3.00 \times 10^{8}\ m/s$

PUT ANSWERS TO MATH PROBLEMS ON LINE AT RIGHT; SHOW YOUR WORK; UNITS COUNT

1. What is the frequency of light with a wavelength of 700nm?

   1. ____________________

2. What color is the light in question 1? 2. __________________

3. How much energy is released when an electron fall's from n=5 to n=2?

   3. ____________________

4. What is the frequency of the light in question 3? 4. _________________

5. What is the wavelength of the light in question 3? 5. _________________

6. What color is the light in question 3? 6. __________________