

1 Everyone has seen a rainbow, but what exactly is a rainbow? The sun produces white
2 light with wavelengths in a visible spectrum, creating a continuous spectrum when passed
3 through a prism. This continuous spectrum is what we see as a rainbow. A line spectrum is a
4 broken rainbow, or a rainbow that only contains certain colors. This type of spectrum contains
5 only certain wavelengths and is produced from excited atoms. This is how light bulbs produce
6 their light: by exciting atoms and letting the atoms fall back to their original energy level. But
7 different light bulbs contain different mechanisms in order to produce their light. Though
8 similar, incandescent and fluorescent light bulbs have very different methods of producing their
9 light and emission spectra. Even more dissimilar is the emission spectra of gaseous hydrogen
10 and its electron transitions.

11 Incandescent and fluorescent lights are similarly produced. Incandescent light bulbs are
12 made with a halogen-gas composition, increasing efficiency (U.S. Dept. of Energy, 2013).
13 Fluorescent lights are made up of mercury, argon gas, two electrodes, and phosphor powder.
14 This makes fluorescent lights even more efficient than incandescent lights (Harris 2001). Both
15 incandescent and fluorescent lights use the idea of exciting electrons in order to emit light, or
16 photons, as seen by Einstein's photoelectric effect, but the process used to get there is a bit
17 unlike. In incandescent lights, electrons are excited by heat in order to make the bulb glow. The
18 light seen is actually the photons being emitted as they return to their initial energy level
19 (Sargosis). Conventional incandescent lights emit a large amount of photons in the ultraviolet
20 spectra, meaning much of its light is lost. Also, because incandescent light bulbs excite their
21 atoms through heat, they lose much energy through heat emission (Harris 2001). In fluorescent
22 light bulbs, a current flows between the two electrodes, causing some of the liquid mercury in
23 the tube to convert to gas. When electrons strike into this mercury gas, the electrons are

1 suddenly excited and are bumped up to higher energy levels (Harris 2001). When the mercury
2 atom's electrons return back to their original energy levels, they emit light photons, also in the
3 ultraviolet spectrum. The phosphor coating on the tube converts the ultraviolet light into the
4 visible light spectrum humans can see, making fluorescent lights much more resourceful than
5 incandescent lights (Harris 2001). When observing these two lights through a diffraction grating
6 slide, an incandescent light will show a red, green, and blue-violet band, while a fluorescent
7 light will show a red, orange, green, turquoise, and purple band. These different wavelengths
8 signify the amount of energy produced from each photon; the electrons with the greatest and most
9 transitions will release the most energy.

10 Hydrogen atoms may go through multiple electron transitions before returning to ground
11 state (Roser, C.). This means they will emit several photons of many different wavelengths. If
12 observed through a diffraction grating slide, hydrogen contains 4 lines: violet, blue-violet, green, and
13 red (Purdue). Using the Bohr model, $E = -Rhc \left[\frac{1}{n(\text{final})^2} - \frac{1}{n(\text{initial})^2} \right]$, the energy levels of the
14 Balmer series can be calculated. The energy level when the $n(\text{initial}) = 6$ is -4.842×10^{-19} , $n(\text{initial})$
15 $= 5$ is -4.576×10^{-19} , $n(\text{initial}) = 4$ is -4.086×10^{-19} , and $n(\text{initial}) = 3$ is -3.026×10^{-19} . As
16 shown, the energy emitted decreases as the energy level decreases. Their wavelengths (in nm)
17 respectively are 410.1 in violet, 434 in blue-violet, 486.1 in green, and 656.2 in red; so as energy level
18 decreases, wavelength increases. Bohr's model works well for hydrogen atoms because they have
19 one electron, but most atoms have far more electrons than this. This is a huge limitation to Bohr's,
20 as it can only effectively be used on hydrogen. Bohr's model also suggests that electrons travel
21 around the nucleus in circular orbits, not elliptical orbits. Essentially, Bohr's model does not fully
22 describe the atom (Docker).

23 Even though Bohr's model is limited exclusively to hydrogen, it is still helpful in
24 understanding and determining the energies and wavelengths of atoms. It explains why several

1 electron transitions in an atom before its return to ground state will emit more photons. The
2 knowledge of a line spectrum, a broken rainbow, and how it's formed has allowed scientists to
3 invent light sources, such as incandescent and fluorescent lights. Excited electrons have enabled
4 different methods to be produced that are more efficient and cost effective. A knowledge of
5 spectrums and the process electrons undergo to create them is essential to the creation every day
6 necessities, such as light.

1 Works Cited

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Calculations

Balmer series:

$$E = -2.179 \times 10^{-18} \text{ J/atom} \left(\frac{1}{2^2} - \frac{1}{6^2} \right) = -4.842 \times 10^{-19}$$

$$E = -2.179 \times 10^{-18} \text{ J/atom} \left(\frac{1}{2^2} - \frac{1}{5^2} \right) = -4.576 \times 10^{-19}$$

$$E = -2.179 \times 10^{-18} \text{ J/atom} \left(\frac{1}{2^2} - \frac{1}{4^2} \right) = -4.086 \times 10^{-19}$$

$$E = -2.179 \times 10^{-18} \text{ J/atom} \left(\frac{1}{2^2} - \frac{1}{3^2} \right) = -3.026 \times 10^{-19}$$

Wavelength:

$$-4.842 \times 10^{-19} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(2.998 \times 10^8 \frac{\text{m}}{\text{s}})}{\lambda} = 410.1 \text{ nm}$$

violet

$$-4.576 \times 10^{-19} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(2.998 \times 10^8 \frac{\text{m}}{\text{s}})}{\lambda} = 434.0 \text{ nm}$$

blue-violet

$$-4.086 \times 10^{-19} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(2.998 \times 10^8 \frac{\text{m}}{\text{s}})}{\lambda} = 486.1 \text{ nm}$$

green

$$-3.026 \times 10^{-19} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(2.998 \times 10^8 \frac{\text{m}}{\text{s}})}{\lambda} = 656.2 \text{ nm}$$

red

Work Sample Evaluation

Subject Area: Chemistry

Task Title: Why Are the Colors in Some Rainbows Broken?

Student Work Sample Title: Spectrum Research

The document was scored using the *CCR Task Bank Rubric*. The final scores are indicated in the following chart.

Scoring Criteria	Insufficient Evidence	Developing	Progressing	Accomplished	Exceeds
Research and Investigation				X	
Ideas and Content				X	
Reading and Analysis			X		
Communication				X	
Organization				X	
Accuracy				X	

Annotations: The following evidence from the work sample and the reviewer’s comments support the scores above. Page and line numbers refer to the original work sample.

Scoring Criteria	Page #	Line #	Commentary about the work sample
Research and Investigation: <i>Locating resources independently and/or identifying information within provided texts</i>	1	11-12	The student uses references such as “US Department of Energy” that are relevant to the topic at hand. It is important for the student to understand the difference between incandescent and fluorescent bulbs in terms of energy usage, especially during our current “energy crisis.”
	4		The work sample includes numerous references.
	4	11-12	The student uses both college websites and “How Stuff Works” for references. If they had accessed printed academic sources and reputable websites only, their score would have been higher.
Ideas and Content: <i>Presenting a thesis and understanding concepts</i>	1	6-10	The work sample has a thesis, coupled with a discussion of the differences in light. The discussion explains why those lights produce broken rainbows when viewed through a diffraction grating.
	1-3		The information presented in the work sample is relevant and appropriate for the topic being explained. The writer includes the limitations of Bohr’s model when explaining the energy levels viewed in an atom.
Reading and Analysis: <i>Evaluating sources and selecting evidence to support the central idea</i>	1-4		The use of more reputable sources in the work sample could have increased the score in this section. The sources chosen by the student were not analyzed for strength or limitations.
	1	21	The student provided limited to basic definitions and explanation of the information presented. The student did not expand on the information they got from these sources.
Communication: <i>Using subject-appropriate language and considering audience</i>	1	14	While there were some grammatical errors in the work sample, the common misuse of then/than occurs in line 14.
	1	16-17	The use of “is a bit unlike” can leave the reader wondering what the writer means. This language is not appropriate for this type of assignment.
Organization: <i>Structuring main ideas and supporting information</i>	1-3		The work sample uses supporting evidence from measurement values in the Balmer Series.
	1-3		The organization of the work sample flows well for the reader. There was an introduction with a thesis statement, a paragraph about various types of light, a paragraph about Bohr’s experiment and its limitations, and conclusion on the different types of light investigated.
Accuracy: <i>Attending to detail, grammar, spelling, conventions, citations, and formatting</i>	1-3		The use of grammar was not an issue when reading the document. In other words, there were no difficulties in understanding what the writer was trying to convey.
	1	19	The in-text citations were not always done correctly.