

**Preparation for Group Activity (Pre-Activity Assignment):
The Line Spectrum of the Hydrogen Atom and Bohr Theory**

PURPOSE: The goal of this assignment is to familiarize you with the quantifiable properties of light (electromagnetic radiation). Describing these properties is important because of their use in *spectroscopy*, the branch of science studying how light interacts with matter. Spectroscopy is the most important tool in chemistry for following the course of chemical reactions and for identifying compounds, which you will see in an upcoming CHEM 1501 lab. Learning about spectroscopy of one type or another will be part of every course in the chemistry curriculum.

GENAI USE: In addition to strengthening your knowledge of light properties, this assignment will help you develop the fundamental skill of connecting chemical concepts to quantitative properties via calculations. Throughout the general chemistry series, you will use and interpret a variety of symbolic equations. As you've seen in class, we've practiced connecting equations to chemical concept with calculations using pencil and paper and an approved calculator, just as you would on an exam. Using GenAI to complete this assignment will cause you to bypass the practice of this essential chemistry skill—thus GenAI tools are not permitted for use while completing this assignment. Note that textbook examples are provided within the tasks below to continue to support your familiarization with the format of documenting calculations.

CRITERIA: Refer to the rubric at the end of this document for this assignment's learning objectives, taken from the Chapter 3 study guide. Qualitative feedback will be provided on a Canvas version of this rubric to reflect your learning progress.

TASKS:

1. Read sections [3.1](#) and [3.2](#) of the OpenStax textbook. After reading, state in words the precise meaning of the equations below. **Be specific.** Don't just say "frequency"—state the frequency of what object. Observe the examples in a. to see how to properly interpret symbolic equations. In cases with multiple equal signs, it is appropriate to say "This is also equal to..." as is shown in the second example. When calculating with a compound equation like the second example, you may focus on the parts that are relevant to your data, e.g. **A = C**.

Examples:

a. $v = \frac{c}{\lambda}$ A wave's frequency (v) is equal to the speed of light (c) divided by the wave's wavelength (λ).

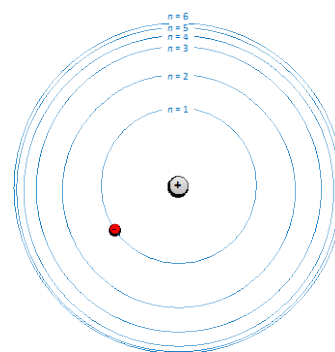
$A = B = C$ The fruit apple (A) is equal to the fruit banana (B). These also equal the fruit cantaloupe (C).

b. $E_{\text{photon}} = hv = \frac{hc}{\lambda}$

c. $E_{\text{photon}} = \Delta E_{\text{electron}} = E_f - E_i$

2. As described in section [3.2](#) of the textbook, Bohr postulated that an electron in a single-electron atom orbits around a positively charged nucleus. The electron “orbits” (levels) are expressed as an integer n (i.e., 1, 2, 3, etc.). The electron has an energy of E_n , as shown in the equation below.

$$E_n = -k\left(\frac{Z^2}{n^2}\right), \text{ where } k = 2.179 \times 10^{-18} \text{ J}$$



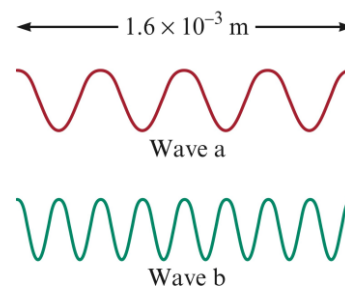
- a. What does Z represent?
- b. Calculate the energy of orbit $n = 2$ or E_2 for a **hydrogen** atom. Observe [Example 3.4](#) in your textbook to see how to properly perform and document your calculations: show the symbolic equation, insert values and units into the equation, and provide the final answer with appropriate units.

3. Below is the emission line spectrum of hydrogen, like [Figure 3.13](#) in your textbook. The wavelength of each line is given in nanometers. Calculate the frequency of each **colored** line (400 and 750 nm are not necessary). Observe [Example 3.1](#) in your textbook to see how to properly perform and document your calculations: show the symbolic equation (re-arrange it if necessary), perform relevant conversions, insert values and units into the equation, and provide the final answer with appropriate units.



4. Complete the following multi-step problem. Make sure to properly perform and document your calculations as described in Tasks 2 and 3, above.

Consider waves **a** and **b**, representing electromagnetic radiation:



- i. Calculate the wavelength of both waves. *Hints:* Recall what “wavelength” means and note the distance scale at the top of the figure to help with your calculations. How many waves (peak-to-peak) “occur” for that distance?

Wave a:

Wave b:

- ii. Which wave has the longer wavelength? *Circle one:* Wave a / Wave b
- iii. Calculate 1) the frequency and 2) the energy for each wave. Which wave has the higher frequency (ν) and larger photon energy (E_{photon})?

Wave **a** frequency and energy:

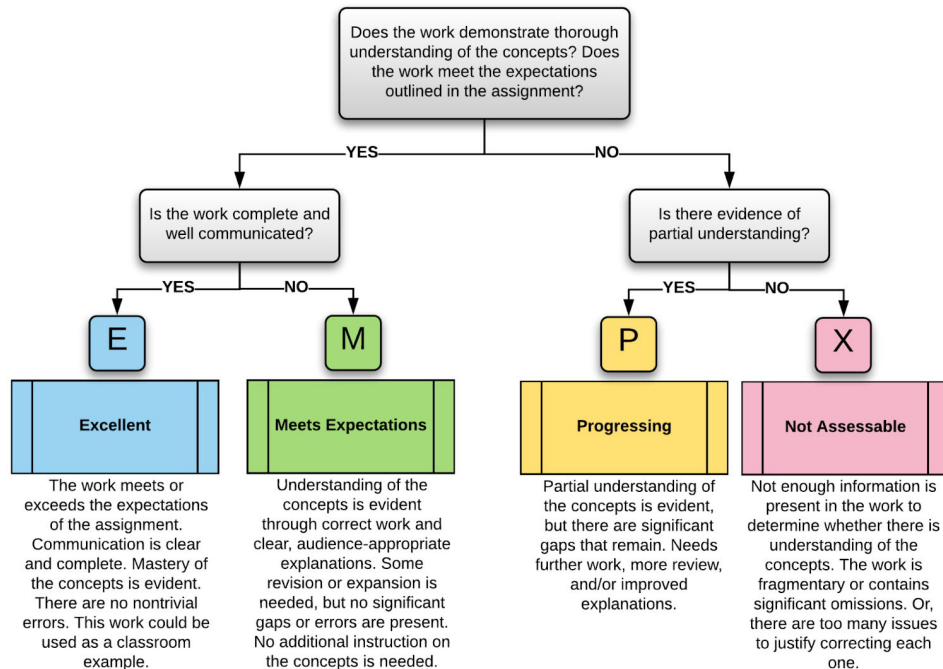
Wave **b** frequency and energy:

- iv. Which wave has the greater velocity? *Hint:* Velocity (m/s) is synonymous with speed.
- v. What type of EM does each wave represent? Refer to [Figure 3.3](#) in your text.

Wave a:

Wave b:

**RUBRIC for Preparation for Group Activity (Pre-Activity Assignment):
The Line Spectrum of the Hydrogen Atom and Bohr Theory**



Tasks 1 and 2 LO 3.5. Recognize the Rydberg formula in terms of energy levels (see the 3 rd equation listed in section 3.2 of the text) and explain its relationship to the hydrogen atom spectrum. In this formula, distinguish between n , E_n , and ΔE .	All equation symbols are clearly and correctly defined. Symbols are correctly related to an object or concept.	Equation symbols are clearly and correctly defined. Symbols are not related to an object or concept or are related to these incorrectly.	Equation symbols are incorrectly defined. Symbols are not related to an object or concept or are related to these incorrectly.	Equation symbols are not defined. Symbols are not related to an object or concept or are related to these incorrectly.
Tasks 3 and 4 LO 3.1. Calculate the wavelength of EM radiation from frequency or the frequency from wavelength. Be able to calculate the energy of a photon from its frequency or wavelength.	Correct problem strategy (shown via symbolic equations provided) + calculation work shows values w/ units inserted in equation + correct final numerical answer w/units.	Correct strategy, i.e. equation provided, that would lead to the correct numerical answer, but either some elements of work are missing or a calculation error is evident.	Correct strategy is evident and/or a numerical answer with (or without) units is provided, with no demonstration of calculations	Equations, values, or work provided does not relate the given question and/or the work is incomplete
Task 4 LO 3.2. Classify the types of light in the electromagnetic spectrum (i.e., gamma, X-ray, UV, etc.) and rank their relative energies, frequencies, and wavelengths.	All calculated wavelength values are interpreted appropriately to match the correct type of electromagnetic radiation.	All calculated wavelength values are interpreted, with some errors in matching to the correct type of electromagnetic radiation.	Wavelength values are interpreted, but with substantial errors or reversing the relative rankings.	Wavelength values are not interpreted and the type of electromagnetic radiation is not provided.