GENERAL CHEMISTRY LABORATORY

CH101

Post-lab assignment on exp. #3

Energy Levels and Electron changes in the hydrogen atom

Name:____

ID#:____

TF:____

Lab section:

BOSTON UNIVERSITY

Exp.#3: Energy Levels and Electron changes in the hydrogen atom

Part A – Light emission from atoms

1. When Li atoms are added to a flame, energy from the flame excites the atoms to higher energy state. The Li atoms emit light at a wavelength of 671 nm.
   a. Calculate the frequency (in Hz) of the light emitted by the Li atoms.

   Frequency = Hz

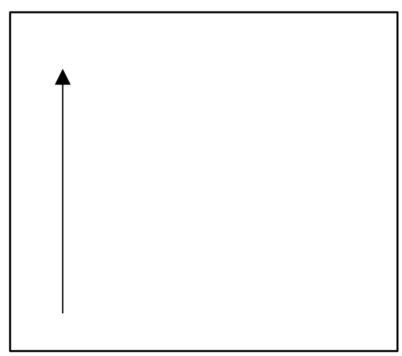
   b. What color do we associate with light of this wavelength? (See figures 4.16 and 4.27 in your textbook)

   Color =

2. Mercury atoms emit light with wavelength 436 nm. What is the color of the light associated with the mercury emission?

   Color =

3. Barium atoms in flames emit light through a process by which an electron undergoes a process in which it loses 3.610×10^{-19} J of energy.
   a. In the box to the right, draw an energy level diagram that represents the change in energy of the barium electron in this process.
   b. The energy lost by the barium electron is emitted as light. What is the wavelength (in nm) and color of this light?



   $\lambda =$ nm

   Color =

Part B – Absorption and emission

4. Consider the emission and absorption spectra for helium:

   a. Which spectrum is the absorption spectrum? (circle your choice)

      A   B   neither

A

B

   b. In your own words, briefly explain what the black lines in spectrum A represent.

   c. In your own words, briefly explain what the colored areas in spectrum A represent.

5. Consider the hydrogen atom spectrum (below). The blue arrow is pointing at the "red line".

   a. During the process that makes the red line, the hydrogen atom electron's energy is … (fill in the blank)

   b. The wavelength of the red line is 656 nm. What is the frequency (in Hz) and energy (in aJ) of the light associated with this line?

Frequency =   Hz

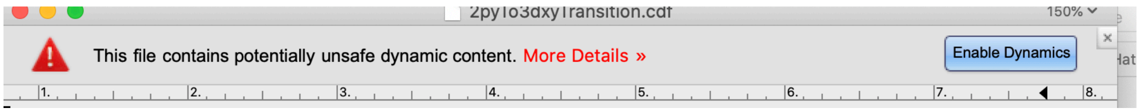
Energy =   aJ

Part C – Simulating absorption of light by an electron

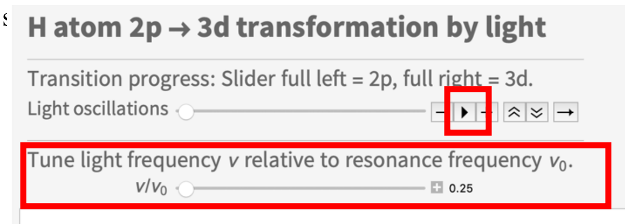
For this part of the experiment you will need to install the (free) Wolfram Player on your computer or look on with another student who has it installed. The link to install the player is: https://www.wolfram.com/player/

After you've installed the wolfram player, download or open the CDF simulation that is posted at: http://quantum.bu.edu/CDF/101/2pyTo3dxyTransition.cdf

Click "Enable Dynamics" so that the simulation will run on your device.



6. Start by tuning the light frequency all the way to the left s
   right).



Once the frequency has been set, press the play button (▶)

a. What do the arrows moving back-and-forth (left-to-right) represent in the simulation?

b. What does the red dot in the middle of the simulation area represent?

c. The blue dumbbell shape represents a hydrogen atom electron wave (the 2p wave, to be precise). What happens to this wave when the simulation is run and the frequency is too low ($\nu/\nu_0 = 0.25$)?

7. Reset the Transition Progress slider (top slider) all the way back to the left. Then, re-tune the light frequency so that the simulation is run at the resonant frequency of the electron wave (i.e., $\nu = \nu_0$ or $\nu/\nu_0 = 1.0$).
   a. Press play again. What do you observe? What is happening to the electron wave?

b. At the end of this simulation, the electron wave has changed. It is now a 3d electron wave. Is the process you observed in (a) absorption or emission? How do you know?

c. Is the process that you observed in (a) instantaneous or gradual?

d. The energy change of the process can be modeled using the formula $E_n = -\frac{2.18\ \text{aJ}}{n^2}$ where n is the number of loops in the electron wave. For 2p, $n = 2$. For 3d, $n = 3$. Based on this, what is the **energy change** ($\Delta E = E_{\text{final}} - E_{\text{initial}}$) in attojoules (aJ) for the electron wave during the process in (a)?

ΔE = aJ

e. As you saw in the simulation, the electron wave has gained energy during this process. The light has lost the exact same amount of energy that the electron has gained (in d). What is the wavelength and color of this light?

λ = nm

Color =

f. This amount of energy – the energy that electron has gained from the light – has a name. What is the name of this *quantity of energy* that the light transfers?

Name =

Part D – Simulating absorption of light by an electron (#2)

Run the simulation at http://quantum.bu.edu/CDF/101/1sTo2pTransition.cdf

8. The initial and final states of the electron wave in this simulation are 1s ($n = 1$) and 2p ($n = 2$).
   a. What is the photon energy, wavelength, and color of the light in the simulation when the light is in resonance with the electron wave?

$E_{\text{photon}} =$ aJ

$\lambda =$ nm

Color =

   b. In no more than one sentence, explain what the word *photon* means.

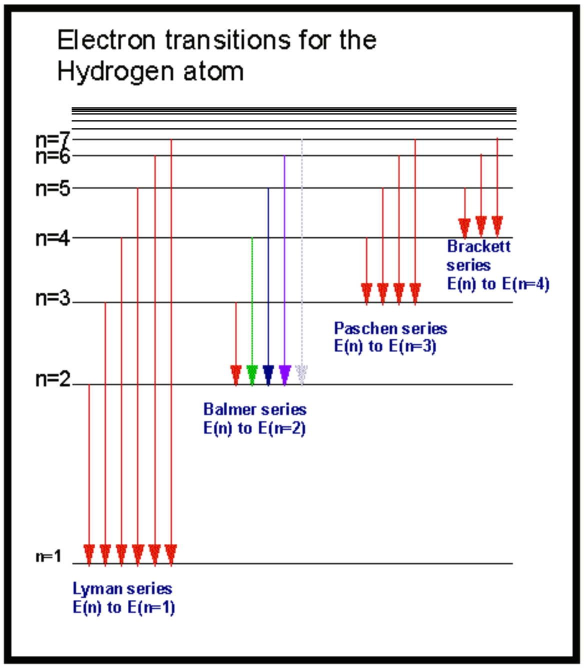
Part E – Follow-up questions

9. Calculate the wavelength λ of the light for the line in the Balmer series of hydrogen spectrum that is the result of an $n = 5$ electron becoming $n = 2$. What is the color of this light?

$\lambda =$ nm

Color =

10. Consider three spectral series for a hydrogen atom: the Lyman, Balmer and Paschen series (see the energy level diagram below).



a. The Balmer series involves only visible light emission. What is true about the Lyman and Paschen emissions?

Circle the correct answer below:

Lyman series			Pashen series		
UV	Visible	Infrared	UV	Visible	Infrared

b. The simulations that we looked at in Parts C and D were both absorptions. The opposite processes are emissions. The emission with the same energy as the change we saw in Part C is part of which series?

c. The emission with the same energy as the change we saw in Part D is part of which series?