Name ______________________

Energy and the Electron: Atomic View and Argumentation

Part I: Warm Up

1. Consider the following questions individually:
   a. What do you know about the structure of the atom?

   b. Draw what you think an atom looks like. Label the different parts of the atom.

   c. What do you think happens to matter (atoms) when you add energy?

Part 2: Exploration

Step 1: Look at the lights in the room or an incandescent light bulb through the spectrophotometer or diffraction grating.

1. What do you notice about the incandescent light bulb as seen with the "naked eye," and observations using the spectroscope or diffraction grating?
   a. Observations – eyes only:

   b. Observations – spectrophotometer/diffraction grating:

2. Using colored pencils, draw what you see from the incandescent light bulb through the spectroscope or diffraction grating.

Step 2: Your instructor will show a gas tube filled with hydrogen gas (hydrogen spectral tube) in a power source. The power source runs an electrical current through the tube at a high voltage. Make observations of the hydrogen gas with your eyes only and then through the spectrophotometer or diffraction grating.

3. What do you notice about the tube of hydrogen gas as seen with the “naked eye,” and observations using the spectrophotometer or diffraction grating?
    a. Observations – eyes only:

    b. Observations – spectrophotometer/diffraction grating:

4. Using colored pencils, draw what you see from the hydrogen gas through the spectrophotometer or diffraction grating:

5. Compare and contrast your observations of the incandescent light with your observations of the hydrogen spectral tube.

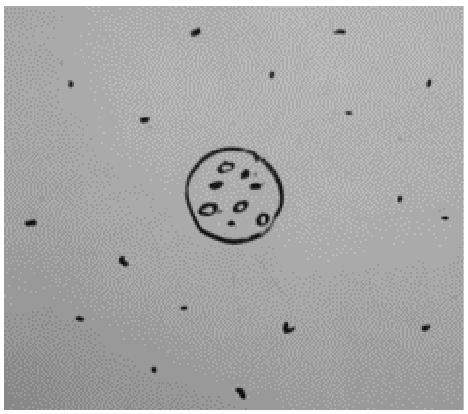
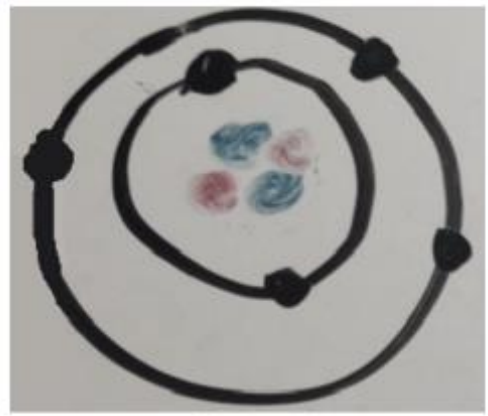
6. Which subatomic particle do you think is affected when energy is added to the atom? Explain.

7. What do you think happens to this subatomic particle when it absorbs energy?

8. What do you think happens to this subatomic particle when it releases energy? Where does this energy go?

STOP! SHARE OUT IDEAS

9. Two students are discussing the following questions: What does the observation of *specific* colored lines (*spectral lines*) tell us about how the electrons are organized outside the nucleus? Examine the responses of the two students below.

Steve	**Rebecca**
I think electrons can be found anywhere outside the nucleus. They are not limited to specific places. When energy is added, these electrons just move around wherever. 	I think electrons can only be found in specific energy levels. When energy is added, electrons can move to higher energy levels. 

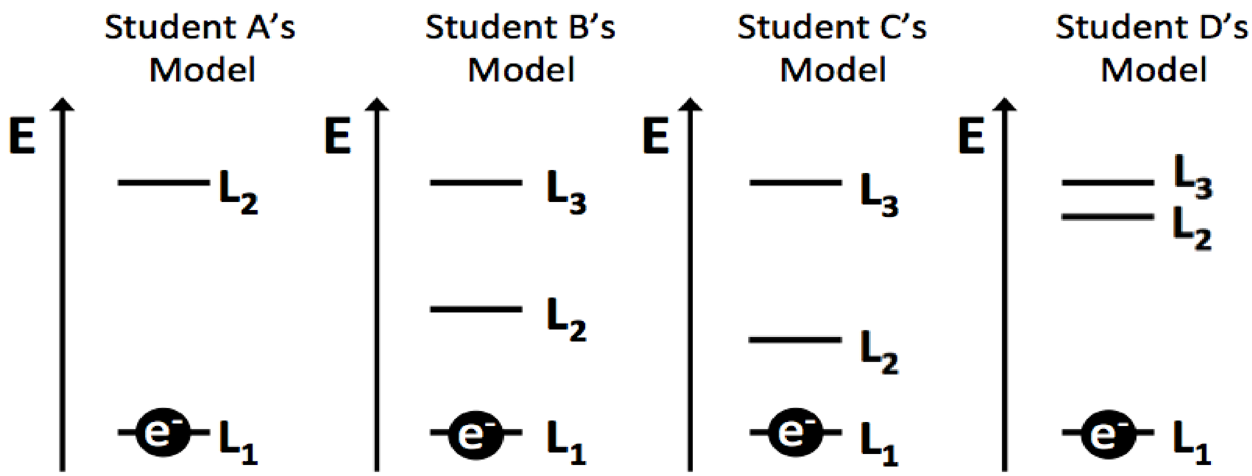
a. What is the main difference between the ideas of these students?

b. If Steve were correct, what would we see when energy is added to the spectral tube?

c. If Rebecca were correct, what would we see when energy is added to the spectral tube?

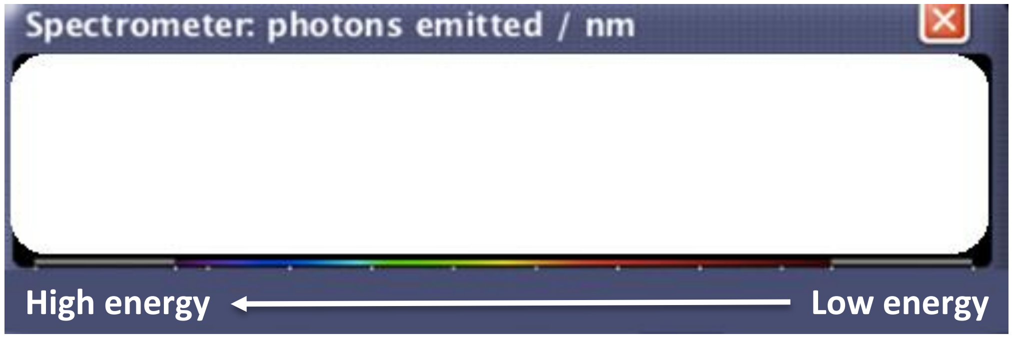
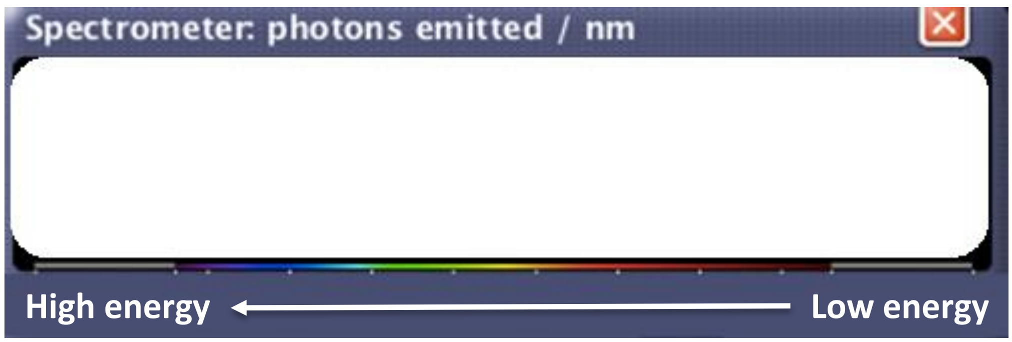
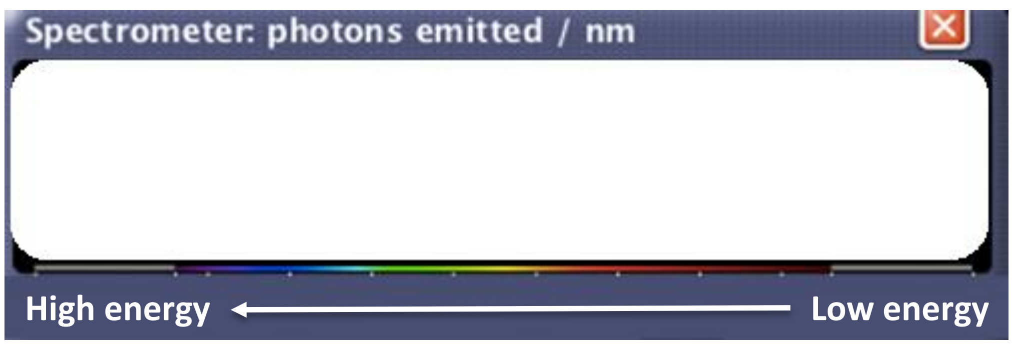
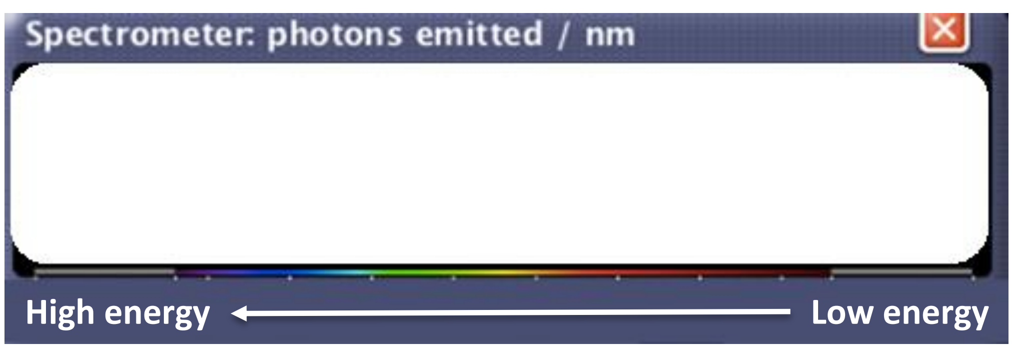
d. Which explanation is best supported by your observations of the hydrogen spectral tube? Explain.

Step 3: Four students are asked to propose a detailed model to represent the different energy levels the electron in a hydrogen atom could take. Their responses are shown below:



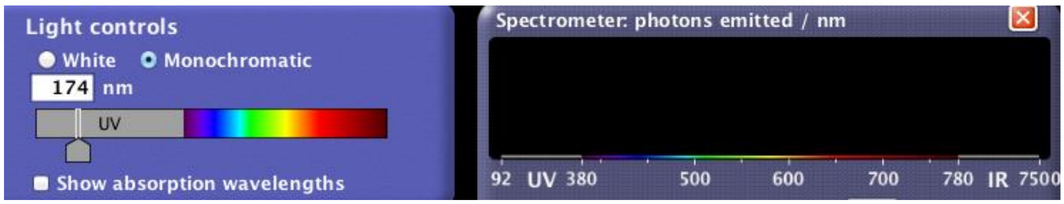
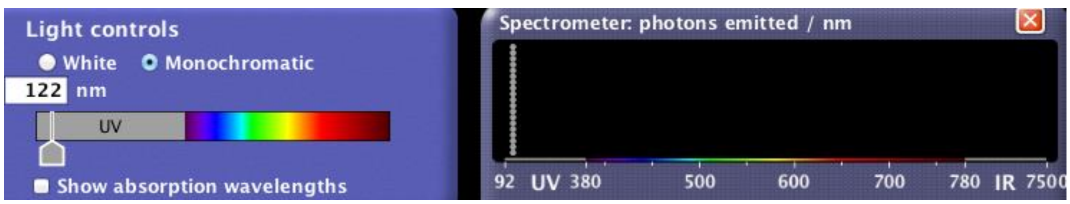
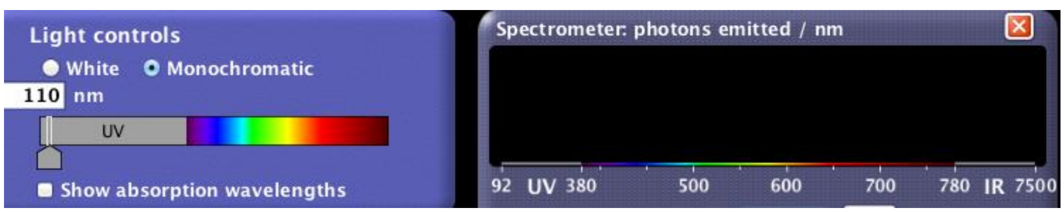
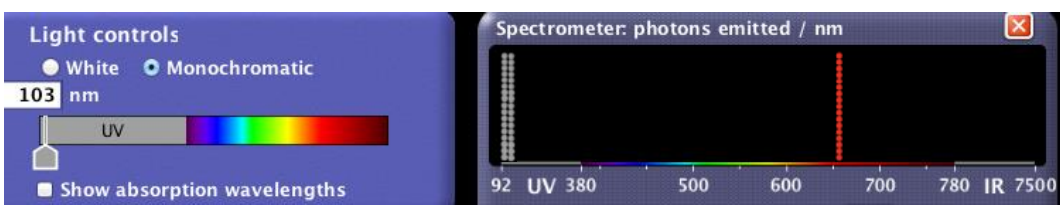
I think there are two possible energy levels. The electron can jump up to level 2 and then fall back to level 1.	I think there are three possible energy levels. The electron can jump up to level 2 or 3, and then fall with the following possibilities: L3 → L2 L3 → L1 L2 → L1 These energy levels are all equally spaced, so the light released will be equally spaced.	I think there are three possible energy levels. The electron can jump up to level 2 or level 3 and then fall with the following possibilities: L3 → L2 L3 → L1 L2 → L1 Energy levels 1 and 2 are a little closer together, and level 3 is a little further from level 2, so two of the colors of released light will be low energy and close together, while one will be high energy.	I think there are three possible energy levels. The electron can jump up to level 2 or level 3 and then fall with the following possibilities: L3 → L2 L3 → L1 L2 → L1 Energy levels 2 and 3 are very close together, and level 1 is significantly further from level 2, so two of the colors of light will be high energy and close together, while one will be low energy.

10. For each student model, predict how many emission lines you would expect to see and their relative locations. Draw these on the spectrometers below.

<table>
<tr><th>Model</th><th>Prediction of emission lines that would appear in the Spectrometer</th></tr>
<tr><td>Student A</td><td>
</td></tr>
<tr><td>Student B</td><td>
</td></tr>
<tr><td>Student C</td><td>
</td></tr>
<tr><td>Student D</td><td>
</td></tr>
</table>

Step 4: Previously we added electrical energy to the hydrogen tube. However, in this simulation, the energy going into the hydrogen gas is light. Recall that the light energy is related to the wavelength. We will represent the amount of energy going in and released (emitted) in terms of its wavelength (λ).

Using the simulation, students are able to expose a sample of hydrogen gas to light energy of *specific* wavelengths. Four experiments are carried out with four different wavelengths (λ). For each incoming wavelength, the students measure the wavelength of the light *emitted,* or given off. Their results are given below:

Experiment 1: **Incoming λ:** 174 nm **Emission λ:** No emission detected	
Experiment 2: **Incoming λ:** 122 nm **Emission λ:** One emission line at 122 nm	
Experiment 3: **Incoming λ:** 110 nm **Emission λ:** No emission detected	
Experiment 4: Incoming λ: 103 nm Emission λ: Three emission lines detected at 103 nm, 122 nm, & 656 nm	

11. Does incoming light energy of **every wavelength** (λ) result in light emissions? Explain.

12. Which student model does the experimental data support? Explain your reasoning.

13. Build an *argument* to support your choice.
    a. Claim

    b. Evidence

    c. Reasoning

STOP! SHARE OUT IDEAS

Part 4: Experimentation
You will now work with your group to further explore the model of the hydrogen atom. Additional experiments using the same tube of hydrogen exposed to various wavelengths of light have been conducted and the results are provided for you. With your group, examine and discuss the results of each experiment. Use the data and information you collect to answer questions that follow.

Complete the data in the table below. Results of the previous four experiments are already recorded.

Incoming Wavelength (λ)	**Observed Emission Wavelength** (λ)
94 nm	
103 nm	*Three emissions: 103 nm, 122 nm, & 656 nm (Experiment 4)*
108 nm	
110 nm	*No emission detected (Experiment 3)*
115 nm	
122 nm	*One emission at 122 nm (Experiment 2)*
174 nm	*No emission detected (Experiment 1)*
326 nm	
white light	