Name: _____ Date: _____

Student Exploration: Bohr Model: Introduction

Vocabulary: absorption spectrum, Bohr model, electron volt, energy level, laser, orbital, photon

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
When light passes through a gas, certain wavelengths of the light are absorbed. The result is a unique **absorption spectrum**. Two examples are shown below.

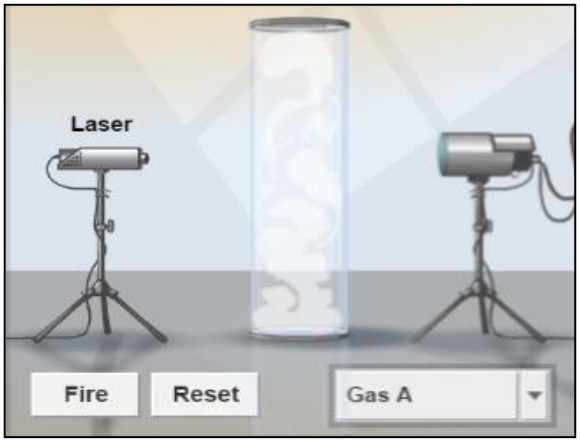
1. What colors of light are absorbed by hydrogen gas? _____

   _____

2. What colors of light are absorbed by helium gas? _____

   _____

Gizmo Warm-up
In 1913, Niels Bohr proposed that the unique spectral lines created by different elements were related to the way electrons were arranged around the nucleus. The *Bohr Model: Introduction* Gizmo™ explores this connection.

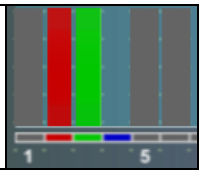


The **laser** shown in the Gizmo can emit **photons**, or particles of light, at a variety of wavelengths. The energy of a photon, measured in **electron volts** (eV), is inversely proportional to its wavelength. Photons that pass through the gas are detected by the photon detector at right.

1. With the **Energy (eV)** set to 1 eV, click **Fire**. Did the photon go straight through the gas in the tube, or was it absorbed by the gas? _____

2. Set the **Energy (eV)** to 4 eV, and click **Fire**. What happened this time? _____

   _____

Activity A: **Absorption spectra**	Get the Gizmo ready: • On the SIMULATION pane, select **Lamp**. • Check that **Gas A** is selected.	

Introduction: The smaller the wavelength of a photon, the greater its energy. We can see photons with wavelengths between 700 nanometers (red) and 400 nanometers (violet), corresponding to energies between 1.8 and 3.1 eV.

Question: What does the absorption spectrum of an element indicate about its electron configuration?

1. Record: Click **Fire**. The lamp emits photons of 1 eV, 2 eV, and so on up to 20 eV. The **EL Photon Detector Display** shows the photons that pass directly through the gas. Any missing photons were absorbed by the gas before being reemitted at various angles.

   Which photon energies were absorbed by **Gas A**? _____

2. Observe: Select the **Laser** on the left and the ORBITALS tab on the right. Set the **Energy (eV)** to 4 eV. The atom model at right, called the **Bohr model**, shows the nucleus of the atom as a dark blue dot. Colored rings surrounding the nucleus represent the **orbitals** that the electron (red dot) can follow. The variable "n" represents the orbital number.

   Click **Fire** and watch closely. What happens? _____

   _____

3. Analyze: Click **Fire** again. This time, focus on the colors of the photons that enter and exit the atom.

   A. What color is the incoming 4-eV photon? _____

   B. What happens to the electron when the photon is absorbed? _____

      _____

   C. What color is the emitted photon? _____

   D. What happens to the electron when the photon is emitted? _____

      _____

   E. If necessary, turn on **Show energy of emitted photon(s)**. What is the energy of the emitted photon? _____

(Activity A continued on next page)

Activity A (continued from previous page)

4. Predict: What do you think will happen if you fire a 7-eV photon at the atom of **Gas A**? How about a 13-eV or a 19-eV photon? _____

_____

_____

5. Gather data: Test your predictions with the Gizmo and fill in the table below. (The first row has been filled in for you.)

Photon energy	Effect on electron	Energy of emitted photon(s)
4 eV	Electron moves up to n = 2 and then back down to n = 1.	4 eV
7 eV		
13 eV		
19 eV		

6. Analyze: Find the total energy of each set of emitted photons. How does each sum relate to the energy of the absorbed photon? _____

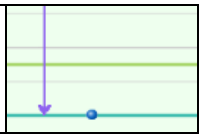
_____

7. Explore: With the **Energy (eV)** set to 19 eV, click **Fire** six times. Record the energy of the emitted photons each time. Record the results of each trial below.

Trial	Energy of emitted photons	Trial	Energy of emitted photons
1		4	
2		5	
3		6	

8. Analyze: When an electron moves from a higher orbital to a lower one, does it always follow the same path? Explain. _____

_____

Activity B: **Energy levels**	Get the Gizmo ready: • Select the ENERGY LEVELS tab. • Check that **Gas A** is selected.	

Introduction: When an electron absorbs a photon, it gains energy, causing it to move to a higher orbit. Because each possible orbit is associated with a specific amount of energy, the orbits are known as **energy levels**. Each element has a unique set of energy levels.

Question: How are energy levels related to absorption spectra?

1. Record: By convention, an energy of 0 eV is assigned to the energy level that is infinitely far from the nucleus. As a result, each energy level is assigned a negative energy value. The energy levels for **Gas A** are shown on the graph. What is the energy of each level?

   n = 1: _____ n = 2: _____ n = 3: _____ n = 4: _____ n = 5: _____

2. Calculate: How much energy would an electron have to gain to move from n = 1 to n = 4?

   _____

3. Test: Set the **Energy (eV)** to this level and click **Fire**. What happened? _____

   _____

4. Make connections: Recall that **Gas A** absorbs photons with the following energies: 4 eV, 7 eV, 13 eV, and 19 eV. How do these values relate to the energy level diagram? Test your ideas using the Gizmo.

   _____

   _____

   _____

5. Record: Each element has a unique configuration of energy levels. Select **Gas B** and record the energy of each energy level for this gas.

   n = 1: _____ n = 2: _____ n = 3: _____ n = 4: _____ n = 5: _____

6. Predict: Based on these energy levels, which photons do you expect **Gas B** to absorb?

   _____

(Activity B continued on next page)

Activity B (continued from previous page)

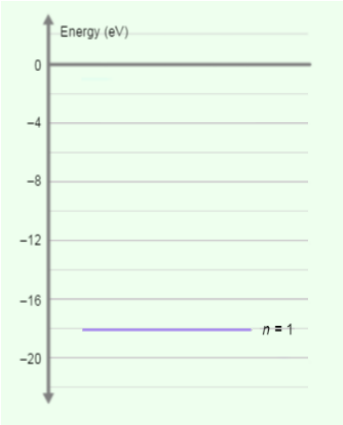
7. Test: Select the **Lamp** and click **Fire**. Which photons were absorbed by **Gas B**?

_____

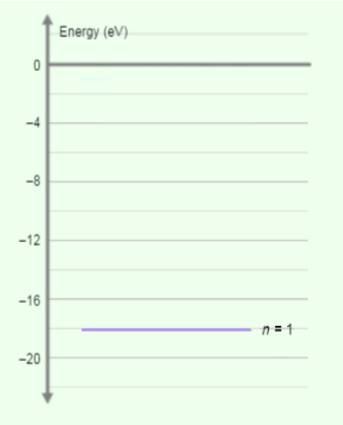
8. Record: Select **Gas C** and click **Fire**. Which photons were absorbed by **Gas C**?

_____

9. Apply: Select the **Laser**. Based on the data you collected, draw an energy levels graph for **Gas C**. When you have finished, select the ENERGY LEVELS tab to check your answer. Fill in the actual graph on the right. (Hint: In **Gas C**, the first energy level is -18 eV.)

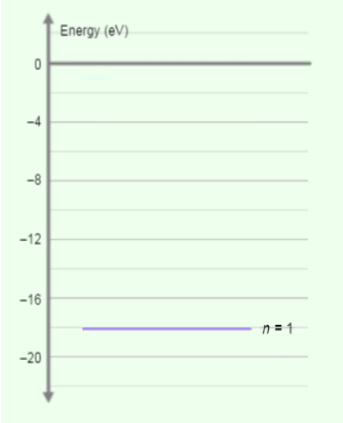


Predicted

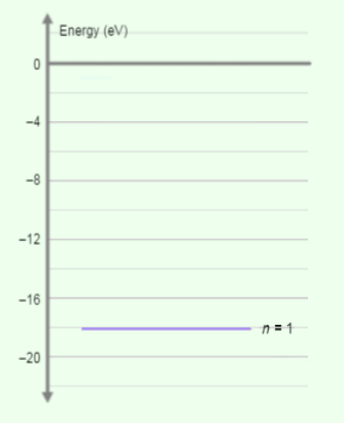


Actual

10. Practice: For **Mystery A** and **Mystery B**, you are not given the actual energy level diagram. Use the **EL Photon Detector Display** to infer the energy level diagrams for each mystery element. (Hint: For each mystery gas, assume the first energy level is -20 eV.)



Mystery A



Mystery B