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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. What colors of light are absorbed by helium gas? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **Activity A:** **Absorption spectra** | Get the Gizmo ready: * On the SIMULATION pane, select **Lamp**.
* Check that **Gas A** is selected.
 | 510SE2 |

**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**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. 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 purple dot. Colored rings surrounding the nucleus represent the **orbitals** that the electron (blue dot) can follow. The variable “n” represents the orbital number.

Click **Fire** and watch closely. What happens? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. Analyze: Click **Fire** again. This time, focus on the colors of the photons that enter and exit the atom.
	* 1. What color is the incoming 4-eV photon? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
		2. What happens to the electron when the photon is absorbed? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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* + 1. What color is the emitted photon? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
		2. What happens to the electron when the photon is emitted? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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* + 1. 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)**

1. 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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. 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 |  |  |

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

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1. 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 |  |

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

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| **Activity B:** **Energy levels** | Get the Gizmo ready: * Select the ENERGY LEVELS tab.
* Check that **Gas A** is selected.
 | 510SE3 |

**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: \_\_\_\_\_\_

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

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1. Test: Set the **Energy (eV)** to this level and click **Fire**. What happened? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. 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.

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1. 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: \_\_\_\_\_\_

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

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**(Activity B continued on next page)Activity B (continued from previous page)**

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

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

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1. 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**

1. 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**