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Modern
Spectra Lab

Essential Questions
1. What happens if a material absorbs a photon?
2. Does the number of photons absorbed equal the number of photons emitted?
3. What does "certainty" mean on the atomic scale?
4. Does humankind benefit more from fission or fusion?

Enduring Understanding - Modern physics studies the smallest particles in nature in order to develop a deeper understanding of fundamental processes.

Background

Physics had explained all observable phenomena as of 1900 except for: blackbody radiation, photoelectric effect and atomic spectra. It was believed, once these were explained, the study of physics would be complete. This assumption was wrong and led to a new branch of physics known today as quantum mechanics.

This card game will investigate atomic spectra. Spectra are produced when an atom absorbs or emits specific amounts of energy. When the atom absorbs energy, the electron moves to a higher energy level; the electron moves away from the nucleus. When the atom emits energy, the electron moves to a lower energy level; the electron moves towards the nucleus. The specific energies absorbed or emitted are an atomic fingerprint and unique to each element.

Niels Bohr successfully created a quantum model of the atom in 1913. His model placed the electrons in discrete, i.e. specific, orbits. The orbit closest to the nucleus is called ground state or energy level - E_1. The energy level number increases, E_2, E_3, E_4, etc., as the discrete orbits move away from the nucleus. Since the electron is bound to the nucleus, all orbital energies are negative. When the electron reaches a position where it is no longer bound to the nucleus, the electron has reached a position called ionization and has an energy equal to zero.

Keywords

Discrete Orbits - The difference in any two energy levels is the energy that can either be absorbed or emitted by the orbiting electrons. The notation used to represent the energy change of the electron is $E_{initial} - E_{final}$.
- Absorbing energy means the electron has moved away from the nucleus, for example $E_2 - E_3$.
- Emitting energy means the electron has moved towards the nucleus, for example $E_3 - E_2$.

Spectra Activity

Part 1 – Absorbing
1. Write the energy level values on your energy level diagram.
   - E_1 = -13 eV, E_2 = -7 eV, E_3 = -2 eV, Ionization = 0 eV
2. Using a deck of cards, place a card in the dashed squares that equals the energy absorbed for the following jumps: $E_1 - E_2$, $E_2 - E_3$, $E_3 - E_{Ionization}$
3. Circle the correct sets of arrows on the diagram that represent jumping up.
4. After completing your energy level diagram, call your teacher over for a follow up question(s).

Part 2 – Emitting
1. Write the energy level values on your energy level diagram.
   - E_1 = -15 eV, E_2 = -7 eV, E_3 = -3 eV, Ionization = 0 eV
2. Using a deck of cards, place a card in the dashed squares that equals the energy emitted for the following jumps: $E_2 - E_1$, $E_3 - E_2$, $E_{Ionization} - E_3$
3. Circle the correct sets of arrows on the diagram that represent jumping down.
4. After completing your energy level diagram, call your teacher over for a follow up question(s).

Part 3 – Larger Jumps

Jumps don't have to be between adjacent energy levels.

- Electrons can jump down between any two energy levels. The difference in energy levels equals the energy emitted.
- Electrons can jump up between any two energy levels. The energy absorbed **MUST** equal the difference between energy levels.

1. Write the energy level values on your energy level diagram.
   - E_1 = -10 eV, E_2 = -5 eV, E_3 = -2 eV, Ionization = 0 eV
2. Draw arrows the represent the 6 possible jumps.
3. Calculate the value of each jump. There are six possible jumps.
4. Place a playing card on the energy level diagram that equals the value of each jump.
5. After completing your energy level diagram, call your teacher over for a follow up question(s).

Part 4 – Check Your Understanding

1. What happens when an electron jumps down?

2. How can an electron jump up?

Part 5 – Calculating Energy Levels

Hydrogen's energy levels can be calculated using the formula - $E_n = \frac{E_1}{n^2} = \frac{-13.6eV}{n^2}$

1. Draw energy levels: E_4, E_5 and E_6 on your energy level diagram.
2. Calculate the first six energy levels for hydrogen.
3. Record your answers on your energy level diagram
4. After completing your energy level diagram, call your teacher over for a follow up question(s).

Part 6 – What do you think?

1. What's the greatest amount of energy an atom can emit?

2. Can an atom absorb more energy than E_1? If yes, what happens?

3. When an electron jumps down it emits energy. If three of the many possible emissions were red, green and blue light what would the spectrum for this element look like?

   This spectrum is called: bright line, dark line, emission or absorption. Circle all that are correct.

4. When an electron jumps up it absorbs energy. If three of the many possible absorptions were red, green and blue light what would the spectrum for this element look like?

   This spectrum is called: bright line, dark line, emission or absorption. Circle all that are correct.