The N = 5 To N = 3 Transition In The Bohr Hydrogen Atom Corresponds To The ____________ Of A Photon With

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Understanding the behavior of electrons within the hydrogen atom has been a cornerstone of quantum physics. One of the most fundamental frameworks used to describe these phenomena is the Bohr model, which simplifies the complex quantum behavior into discrete energy levels. A key aspect of these energy levels is how electrons transition from one to another, emitting or absorbing photons in the process. In particular, the transition from the N = 5 to N = 3 energy level in the Bohr hydrogen atom corresponds to the emission of a photon with specific energy, wavelength, and frequency. This article explores the significance of this transition, the nature of the emitted photon, and how it fits into the broader context of atomic physics.

Understanding the Bohr Model and Electron Transitions

Basics of the Bohr Model

The Bohr model, proposed by Niels Bohr in 1913, revolutionized our understanding of atomic structure by introducing quantized energy levels for electrons orbiting the nucleus of hydrogen. According to this model:

- Electrons revolve around the nucleus in specific, quantized orbits without radiating energy.
- Each orbit corresponds to a discrete energy level, characterized by a principal quantum number N (N = 1, 2, 3, ...).
- Electrons can transition between these levels by absorbing or emitting photons with energies equal to the difference between the initial and final energy levels.

Electron Transitions and Photon Emission

When an electron drops from a higher energy level (say, N = 5) to a lower one (N = 3), it must release energy in the form of a photon. Conversely, when an electron absorbs a photon with the right energy, it can move from a lower to a higher energy level. The energy (E) of the photon emitted or absorbed during such a transition is given by:

$$ E = h \times \nu = \frac{hc}{\lambda} $$

where:

- h is Planck's constant (~6.626×10^{-34} Js),
- ν (nu) is the frequency of the photon,
- c is the speed of light (~3.00×10^{8} m/s),
- λ (lambda) is the wavelength of the photon.

The specific energy difference between levels determines the properties of the emitted photon, including its energy, wavelength, and frequency.

The N = 5 to N = 3 Transition in Hydrogen

Calculating the Energy Difference

In hydrogen, the energy levels are given by the Bohr formula:

$$ E_N = -13.6\, \text{eV} \times \frac{1}{N^2} $$

where N is the principal quantum number. The energy difference (ΔE) for the N=5 to N=3 transition is:

$$
\begin{aligned}
\Delta E &= E_3 - E_5 \\
&= \left(-\frac{13.6\, \text{eV}}{3^2}\right) - \left(-\frac{13.6\, \text{eV}}{5^2}\right) \\
&= -\frac{13.6\, \text{eV}}{9} + \frac{13.6\, \text{eV}}{25} \\
&= -1.511\, \text{eV} + 0.544\, \text{eV} \\
&= -0.967\, \text{eV}
\end{aligned}
$$

The negative sign indicates energy release. The photon emitted has an energy of approximately 0.967 eV.

Determining the Photon's Wavelength and Frequency

Using the relation $E = h \times \nu = \frac{hc}{\lambda}$, the wavelength ($\lambda$) of the emitted photon is:

$$
\lambda = \frac{hc}{E}
$$

Substituting known values:

$$
\begin{aligned}
\lambda &= \frac{(6.626 \times 10^{-34}\, \text{Js})(3.00 \times 10^{8}\, \text{m/s})}{0.967\, \text{eV} \times 1.602 \times 10^{-19}\, \text{J/eV}} \\
&= \frac{(1.9878 \times 10^{-25}\, \text{Js·m})}{1.551 \times 10^{-19}\, \text{J}} \\
&\approx 1.28 \times 10^{-6}\, \text{m}
\end{aligned}
$$

This wavelength of approximately 1280 nm falls within the infrared region of the electromagnetic spectrum.

The frequency (ν) of the photon is:

$$
\nu = \frac{E}{h} = \frac{0.967\, \text{eV} \times 1.602 \times 10^{-19}\, \text{J/eV}}{6.626 \times 10^{-34}\, \text{Js}} \approx 2.34 \times 10^{14}\, \text{Hz}
$$

Summary: The N=5 to N=3 transition in the hydrogen atom results in the emission of a photon with approximately 0.967 eV of energy, a wavelength near 1280 nm, and a frequency around 234 THz.

Significance of the Transition and the Emitted Photon

Spectroscopic Implications

This transition contributes to the spectral lines observed in the hydrogen emission spectrum, notably in the infrared region. These spectral lines serve as crucial evidence for quantized energy levels and have been instrumental in validating quantum theory.

Astrophysical Relevance

Hydrogen spectral lines, including those from the N=5 to N=3 transition, are observed in stellar spectra and interstellar medium studies. They help astronomers determine the composition, temperature, and motion of celestial objects.

Educational and Scientific Importance

Understanding this transition provides insight into:

- The quantization of atomic energy levels,
- The principles behind spectral line formation,
- The development of quantum mechanics and its applications.

Broader Context: The Nature of Photons and Atomic Transitions

Photon Emission and Absorption

The N=5 to N=3 transition exemplifies the fundamental process where electrons lose energy by emitting photons. Conversely, electrons can gain energy by absorbing photons matching the energy difference. These interactions underpin many technologies, including lasers, spectroscopy, and quantum computing.

Types of Transitions and Their Corresponding Photons

Different electron transitions produce photons across the electromagnetic spectrum:

- Ultraviolet transitions (e.g., N=2 to N=1)
- Visible transitions (e.g., N=3 to N=2)
- Infrared transitions (e.g., N=5 to N=3)

The energy, wavelength, and frequency of emitted photons vary accordingly, enabling diverse applications and observations.

Conclusion

The transition from N=5 to N=3 in the Bohr hydrogen atom corresponds to the emission of a photon with approximately 0.967 eV of energy, a wavelength around 1280 nm, and a frequency near 234 THz. This process exemplifies the quantized nature of atomic energy levels and the fundamental emission process in quantum physics. Understanding these transitions not only deepens our comprehension of atomic structure but also underpins numerous scientific and technological advancements, from spectroscopy to astrophysics. The precise characteristics of the emitted photon serve as a window into the quantum world, illustrating how tiny energy differences manifest as observable electromagnetic radiation across the spectrum.

Frequently Asked Questions

What does the transition from N=5 to N=3 in the Bohr hydrogen atom correspond to?

It corresponds to the emission of a photon with a specific wavelength and energy equal to the difference between the energy levels N=5 and N=3.

How is the energy of the photon related to the N=5 to N=3 transition in the Bohr model?

The energy of the photon equals the difference in energy levels between N=5 and N=3, calculated using the Rydberg formula: $E = R (1/n_1^2 - 1/n_2^2)$.

What type of electromagnetic radiation is emitted during the N=5 to N=3 transition?

It emits a photon in the visible or ultraviolet range, depending on the exact energy difference between the levels.

How can the wavelength of the photon emitted in the N=5 to N=3 transition be calculated?

Using the Rydberg formula: $\lambda = hc / \Delta E$, where ΔE is the energy difference between the levels, or directly via the Rydberg equation for hydrogen.

What is the significance of the N=5 to N=3 transition in understanding atomic spectra?

It explains the spectral lines observed in hydrogen emission spectra, specifically the Balmer series in the visible region.

Does the N=5 to N=3 transition correspond to an emission or absorption process?

It corresponds to an emission process, where the atom emits a photon as it transitions from a higher to a lower energy level.

What is the energy of the photon emitted during the N=5 to N=3 transition in electron volts (eV)?

The energy can be calculated using $\Delta E = R (1/3^2 - 1/5^2)$, then converting the result into electron volts.

In the context of the Bohr model, what quantum number change occurs during the N=5 to N=3 transition?

The principal quantum number decreases from n=5 to n=3, with $\Delta n=2$.

Why is the N=5 to N=3 transition important for spectroscopy studies?

It helps in understanding the spectral lines of hydrogen, allowing precise measurements of atomic energy levels and validation of quantum theory.

Additional Resources

The N = 5 To N = 3 Transition In The Bohr Hydrogen Atom Corresponds To The __________ Of A Photon With

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Introduction

The Bohr model of the hydrogen atom revolutionized our understanding of atomic structure, providing a quantized framework where electrons occupy discrete energy levels characterized by quantum numbers. Transitions between these levels are associated with the absorption or emission of photons, each carrying a precise amount of energy corresponding to the difference between initial and final states. Among these, the transition from the N=5 to N=3 energy level has garnered significant interest, not only for its spectral characteristics but also for its implications in quantum mechanics and spectroscopy.

This article aims to thoroughly investigate the physical phenomena associated with the N=5 to N=3 transition in the Bohr hydrogen atom, focusing particularly on the nature of the emitted photon. The blank in the phrase "corresponds to the __________ of a photon with" will be explored in depth, examining whether it refers to the energy, frequency, wavelength, quantum, or other properties of the photon. Through a detailed analysis rooted in quantum theory, electromagnetic radiation principles, and spectroscopic data, we aim to clarify the fundamental relationship between atomic transitions and photon characteristics.

Historical Context and Theoretical Foundations

The Bohr Model and Quantized Energy Levels

Niels Bohr's model posited that electrons orbit the nucleus in specific, quantized circular orbits, with energy levels labeled by the principal quantum number N. These energy levels are given by:

$$ E_N = -\frac{13.6\, \text{eV}}{N^2} $$

for hydrogen, where N is an integer (1, 2, 3, ...). Transitions between levels involve absorption or emission of photons with energies equal to the difference between initial and final states:

$$ \Delta E = E_{N_{initial}} - E_{N_{final}} $$

which, when emitted as a photon, relates to the photon’s properties.

Spectral Lines and Transition Types

In the hydrogen spectrum, the transition from N=5 to N=3 produces a specific spectral line. Such lines are classified as Balmer series lines when involving N=2 as the lower level, but higher-level transitions like N=5 to N=3 generate lines in the ultraviolet or visible regions depending on the energy difference.

Quantitative Analysis of the N=5 to N=3 Transition

Calculating the Transition Energy

Using the Bohr energy formula:

$$
E_N = -13.6\, \text{eV} / N^2
$$

we find:

$$
E_5 = -13.6\, \text{eV} / 25 = -0.544\, \text{eV}
$$

$$
E_3 = -13.6\, \text{eV} / 9 \approx -1.511\, \text{eV}
$$

The energy difference:

$$
\Delta E = E_3 - E_5 = -1.511\, \text{eV} - (-0.544\, \text{eV}) = -0.967\, \text{eV}
$$

The negative sign indicates emission; the photon emitted carries positive energy:

$$
E_{photon} = 0.967\, \text{eV}
$$

Corresponding Wavelength and Frequency

Using the relation:

$$
E_{photon} = h\nu = \frac{hc}{\lambda}
$$

where:

- h is Planck's constant $\approx 6.626 \times 10^{-34}\, \text{Js}$,
- c is the speed of light $\approx 3.00 \times 10^8\, \text{m/s}$,
- λ is the wavelength,
- ν is the frequency.

Calculating wavelength:

$$
\lambda = \frac{hc}{E_{photon}}
$$

Converting energy to joules:

$$
E_{photon} = 0.967\, \text{eV} \times 1.602 \times 10^{-19}\, \text{J/eV} \approx 1.55 \times 10^{-19}\, \text{J}
$$

Thus:

$$
\lambda = \frac{6.626 \times 10^{-34} \times 3.00 \times 10^8}{1.55 \times 10^{-19}} \approx 1.28\, \text{μm}
$$

\]

Corresponding frequency:

$$
\nu = \frac{E_{photon}}{h} \approx \frac{1.55 \times 10^{-19}}{6.626 \times 10^{-34}} \approx 2.34 \times 10^{14}\, \text{Hz}
$$

The Nature of the Emitted Photon

Given the calculations above, the transition from N=5 to N=3 corresponds to a photon with:

- Energy: approximately 0.967 eV,
- Wavelength: approximately 1.28 micrometers,
- Frequency: approximately 2.34×10^{14} Hz.

The question at hand is: The N=5 to N=3 transition in the Bohr hydrogen atom corresponds to the __________ of a photon with.

Deep Dive: What Property of the Photon Does This Transition Correspond To?

1. The Energy of the Photon

The primary property directly associated with atomic energy level transitions is the photon's energy. The quantized energy difference between the initial and final states manifests as the photon's energy, as mandated by the conservation of energy principle.

Implication: The transition corresponds to the energy of the photon.

2. The Frequency of the Photon

Since energy and frequency are directly proportional ($E = h\nu$), the transition also determines the photon's frequency uniquely. The higher the energy difference, the higher the frequency.

Implication: The transition corresponds to the frequency of the photon.

3. The Wavelength of the Photon

Similarly, wavelength and energy are inversely related via $\lambda = c / \nu$. Knowing the energy difference allows calculation of the wavelength.

Implication: The transition corresponds to the wavelength of the photon.

4. The Quantum of Energy

In quantum mechanics, a photon is a quantum of electromagnetic energy. The transition between discrete energy levels signifies the emission of a quantum of electromagnetic radiation with that specific energy.

Implication: The transition corresponds to the quantum of the photon.

Quantum Mechanical Perspectives

While classical electromagnetic theory emphasizes the wavelength and frequency, quantum mechanics underscores the photon as a discrete quantum of energy. The Bohr model’s simplistic picture aligns with the photon as a quantum of energy, but modern quantum electrodynamics (QED) refines this understanding further.

Energy Quantization and Photon Properties

- The discrete energy emitted during an atomic transition directly corresponds to the photon’s energy quantum.
- The frequency and wavelength are derived from this energy, but they are secondary properties in the fundamental quantum description.
- The quantum of electromagnetic energy emitted or absorbed during a transition encapsulates the core concept.

Spectroscopic Significance

The N=5 to N=3 transition produces spectral lines that are observed in specific regions of the electromagnetic spectrum. The precise wavelength allows spectroscopists to identify the transition and infer properties about the atom and its environment.

Broader Implications and Applications

- Astrophysics: These spectral lines serve as fingerprints for hydrogen in stellar atmospheres.
- Laser Physics: Understanding transitions underpins laser design and operation.
- Quantum Information: Transitions between discrete states form the basis of quantum bits (qubits).

Conclusion

The investigation into the N=5 to N=3 transition in the Bohr hydrogen atom reveals that it corresponds to the quantum of a photon with specific energy, frequency, and wavelength. Given the fundamental nature of quantum theory, the most precise and comprehensive descriptor is the quantum—the discrete packet of electromagnetic energy emitted during the atomic transition.

Therefore, the complete phrase reads:

The N=5 To N=3 Transition In The Bohr Hydrogen Atom Corresponds To The Quantum Of A Photon With

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References

- Bohr, N. (1913). On the Constitution of Atoms and Molecules. Philosophical Magazine, 26(151), 1-25.
- Griffiths, D. J. (2018). Introduction to Quantum Mechanics. Cambridge University Press.
- Tipler, P. A., & Llewellyn, R. (2008). Modern Physics. W. H. Freeman.
- Herzberg, G. (1950). Molecular Spectra and Molecular Structure. Van Nostrand Reinhold.

This comprehensive analysis underscores the profound link between atomic energy levels and photon properties, illustrating the quantum nature of electromagnetic radiation emitted during atomic transitions.

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