

A Simple Atom Has Only Two Absorption Lines, At 270 Nm And 670 Nm. What Is The Wavelength Of The One Line

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Understanding atomic absorption lines is fundamental in the study of atomic physics and spectroscopy. When examining a simple atom with only two distinct absorption lines at specific wavelengths—270 nanometers (Nm) and 670 Nm—it becomes crucial to analyze what these lines represent and how they relate to atomic transitions. This article explores the nature of absorption lines, their significance, and how to interpret the given wavelengths to identify the specific line in question.

What Are Atomic Absorption Lines?

Definition and Significance

Atomic absorption lines are dark lines or bands observed in a spectrum, representing specific wavelengths where atoms absorb electromagnetic radiation. These absorption lines correspond to the energy differences between quantized energy levels within an atom. When light passes through a medium containing atoms, photons with energies matching the energy gap between two levels are absorbed, resulting in characteristic lines in the spectrum.

Quantum Transitions and Spectral Lines

Atoms have discrete energy levels. Transitions of electrons between these levels involve absorption or emission of photons with specific energies, which directly relate to particular wavelengths via the relation:

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

where:

- ΔE is the energy difference between levels,
- h is Planck's constant,
- ν is the frequency,
- c is the speed of light,
- λ is the wavelength.

Thus, each absorption line corresponds to a specific transition within the atom.

Interpreting the Absorption Lines at 270 Nm and

670 Nm

Given the two absorption lines at 270 Nm and 670 Nm, several questions arise:

- Which line corresponds to which transition?
- What is the wavelength of the other line?
- How do these wavelengths relate to the energy levels involved?

Understanding the Wavelengths

The wavelength at 270 Nm (nanometers) falls within the ultraviolet (UV) region of the electromagnetic spectrum, which ranges from approximately 10 Nm to 400 Nm. The 670 Nm wavelength, on the other hand, is in the visible spectrum, specifically in the red region.

This indicates that the atom exhibits absorption in both UV and visible regions, possibly involving transitions from different energy levels or different electronic states.

Determining the Wavelength of the Other Line

The key question posed is: "What is the wavelength of the one line?" Since the atom has only two absorption lines at 270 Nm and 670 Nm, identifying which one is being asked about is essential. Often, such problems are designed to test understanding of the relationship between absorption lines and energy level transitions.

Possible Scenarios

- If the question asks for the wavelength of the other line when one is known, then the answer is simply the other wavelength, i.e., if one line is at 270 Nm, the other is at 670 Nm, and vice versa.
- Alternatively, if the question aims to determine the energy difference corresponding to one of the lines, then the calculation involves converting the wavelength to energy.

Calculating the Energy of the Absorption Lines

To understand the significance of these absorption lines, calculating their energies provides insight into the electronic transitions involved.

Energy Calculation Formula

Using the relation:

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

where:

- $h = 6.626 \times 10^{-34} \text{ Js}$,
- $c = 3.00 \times 10^8 \text{ m/s}$,
- λ must be in meters.

For $(\lambda = 270 \text{ nm}, E = 270 \times 10^{-9} \text{ J})$:

$$E_{270} = \frac{6.626 \times 10^{-34} \times 3.00 \times 10^8}{270 \times 10^{-9}} \approx 7.37 \times 10^{-19} \text{ J}$$

Converting to electronvolts (eV):

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$E_{270} \approx \frac{7.37 \times 10^{-19}}{1.602 \times 10^{-19}} \approx 4.60 \text{ eV}$$

For $(\lambda = 670 \text{ nm}, E = 670 \times 10^{-9} \text{ J})$:

$$E_{670} = \frac{6.626 \times 10^{-34} \times 3.00 \times 10^8}{670 \times 10^{-9}} \approx 2.97 \times 10^{-19} \text{ J}$$

$$E_{670} \approx \frac{2.97 \times 10^{-19}}{1.602 \times 10^{-19}} \approx 1.85 \text{ eV}$$

These energies suggest that the atom absorbs photons of approximately 4.6 eV and 1.85 eV, corresponding to electronic transitions between specific energy levels.

Implications and Applications

Understanding these absorption lines' wavelengths and energies has broad implications in various fields:

Spectroscopy and Identification of Elements

Spectroscopic analysis relies on absorption lines to identify elements in stars, planets, and laboratory samples. The known wavelengths at 270 nm and 670 nm can help identify the atom if its energy levels are mapped.

Atomic Structure and Energy Level Mapping

The specific wavelengths indicate the energy difference between levels. For example, a transition involving UV absorption at 270 nm might correspond to an excitation from a lower energy level to a higher one, while the visible absorption at 670 nm might involve a different transition.

Designing Lasers and Light Sources

Knowledge of specific absorption lines is essential in designing lasers and other optical devices. The wavelengths determine the operational frequencies and the energy states involved.

Conclusion: Wavelength of the Other Line

In the context of the question, since the atom has only two absorption lines at 270 nm and 670 nm, the wavelength of the other line, given one, is simply the remaining wavelength. For example:

- If the known line is at 270 nm, then the other line is at 670 nm.
- Conversely, if the known line is at 670 nm, then the other is at 270 nm.

This straightforward pairing underscores the importance of understanding absorption spectra and their role in identifying atomic and molecular structures.

Summary of Key Points

- Atomic absorption lines represent specific energy transitions within an atom, corresponding to particular wavelengths.
- The given lines at 270 nm and 670 nm cover UV and visible spectrum regions, indicating multiple electronic transitions.
- Calculating energies from wavelengths provides insight into the electronic structure of the atom.
- The wavelength of the other line in a two-line system is simply the remaining wavelength, highlighting the discrete nature of atomic spectra.
- Understanding these principles is fundamental in spectroscopy, element identification, and optical device design.

In essence, the wavelength of the other line in this simple atomic system is either 270 nm or 670 nm, depending on which line is being referred to. Recognizing this helps in interpreting atomic spectra and understanding atomic energy levels in detail.

Frequently Asked Questions

What are the two absorption lines observed in a simple atom?

The two absorption lines are at 270 nm and 670 nm.

If a simple atom has absorption lines at 270 nm and 670 nm, what is the wavelength of the other line?

The question asks for the wavelength of one line, but since both are given, the other line's wavelength is either 270 nm or 670 nm, depending on which one is being identified.

What is the significance of the 270 nm absorption line in a simple atom?

The 270 nm absorption line indicates a specific electronic transition within the atom corresponding to ultraviolet light absorption.

What information can be inferred from the absorption line at 670 nm?

The absorption line at 670 nm suggests the atom absorbs red light, corresponding to a particular energy level transition.

How does the presence of only two absorption lines affect the electronic structure of the atom?

It suggests the atom has a simple electronic structure with only two prominent energy level transitions detectable via absorption.

Can the wavelength of the other absorption line be determined from the given data?

Yes, if one line's wavelength is known, the other can sometimes be inferred based on the atom's energy levels, but additional data is needed for precise determination.

Why are absorption lines at specific wavelengths important in atomic spectroscopy?

They serve as unique identifiers for elements and help in understanding the atomic energy levels and electronic transitions.

What is the typical energy difference corresponding to the 270 nm absorption line?

The energy difference can be calculated using $E=hc/\lambda$, which for 270 nm corresponds to approximately 4.60 eV.

Is the wavelength of 670 nm in the visible spectrum, and what color does it correspond to?

Yes, 670 nm is in the red region of the visible spectrum, corresponding to deep red light.

Additional Resources

A Simple Atom Has Only Two Absorption Lines, At 270 Nm And 670 Nm. What Is The Wavelength Of The One Line?

Understanding the spectral properties of atoms is fundamental to fields ranging from astrophysics to chemical analysis. Among the intriguing questions scientists often explore is how atoms absorb and emit light at specific wavelengths. Recently, a simple atom has been identified with only two prominent absorption lines: one at 270 nanometers (Nm) and the other at 670 Nm. This raises an interesting question: what is the wavelength of the other absorption line, and what does this tell us about the atom's electronic structure? In this article, we delve into the principles of atomic absorption lines, interpret what these specific wavelengths imply, and explore how scientists decode the spectral signatures of atoms.

The Significance of Absorption Lines in Atomic Spectroscopy

Before focusing on the particular case of this simple atom, it's vital to understand the broader context of absorption lines in atomic spectroscopy.

What Are Absorption Lines?

Absorption lines are dark lines observed in a continuous spectrum when atoms or molecules absorb specific wavelengths of light. Each element or atom has a unique spectral fingerprint, corresponding to the energy differences between its quantized electronic energy levels.

- **Electronic Transitions:** Electrons in an atom occupy discrete energy levels. When they absorb a photon with energy equal to the difference between two levels, they jump to a higher energy state, resulting in an absorption line at a characteristic wavelength.

- **Spectral Signatures:** These lines are unique identifiers for elements, making spectroscopy a powerful tool for identifying the composition of distant stars, chemical samples, and even atmospheric gases.

Why Only Two Absorption Lines?

Most atoms exhibit numerous absorption lines, corresponding to various electronic transitions. However, some atoms, especially those with simple electronic configurations, may have only a few prominent lines. Such simplicity can be advantageous for analytical purposes and helps in understanding fundamental atomic behaviors.

Deciphering the Wavelengths: What Do 270 Nm and 670 Nm Tell Us?

Given that the atom in question exhibits absorption lines at 270 Nm and 670 Nm, we must analyze what these wavelengths suggest about its electronic structure.

The Nature of the Wavelengths

- **270 Nm (Ultraviolet Region):** This wavelength falls within the ultraviolet (UV) spectrum. Transitions here typically involve electrons moving between

lower energy levels or from the ground state to an excited state at higher energy.

- 670 Nm (Red/Visible Region): This wavelength is in the red portion of the visible spectrum. Transitions at this wavelength usually involve energy differences corresponding to lower energy photons compared to UV.

The Energy Difference

Using the relationship between wavelength (λ), energy (E), Planck's constant (h), and the speed of light (c):

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

- At 270 Nm:

$$E_{\text{UV}} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(3 \times 10^8 \text{ m/s})}{270 \times 10^{-9} \text{ m}} \approx 7.36 \times 10^{-19} \text{ J}$$

- At 670 Nm:

$$E_{\text{Red}} = \frac{(6.626 \times 10^{-34})(3 \times 10^8)}{670 \times 10^{-9}} \approx 2.97 \times 10^{-19} \text{ J}$$

These energies reflect the electronic transition differences. The larger energy corresponds to the UV transition, and the smaller to the red transition.

The Electronic Structure of the Atom

Given just two absorption lines, the atom is likely to have a simple electronic configuration, possibly with a few energy levels. Its spectral lines suggest two main transitions:

1. High-energy transition at 270 Nm
2. Lower-energy transition at 670 Nm

This configuration resembles that of a two-level or a simple multi-level atom with dominant transitions.

Possible Electronic Transitions

- The UV line at 270 Nm could correspond to an electron moving from a lower energy level (possibly the ground state) to a higher excited state.
- The visible line at 670 Nm might be a transition from an excited state back to a lower energy level or between two excited states.

The key question: which transition corresponds to which wavelength?

Typically, absorption lines are associated with electrons moving from a lower to a higher energy level, meaning the 270 Nm line indicates a transition from a lower to a higher level, while the 670 Nm line could be associated with a transition from a higher to a lower level, or vice versa, depending on the atom's energy level structure.

Determining the Wavelength of the Other Line

Suppose we are told that the atom has only these two absorption lines, at 270 Nm and 670 Nm, and we want to understand which line corresponds to which transition, or find the wavelength of the other line if one is missing.

Scenario 1: The atom exhibits two absorption lines at 270 Nm and 670 Nm, corresponding to two electronic transitions.

In this case, the wavelengths are fixed, and the question may be asking: which of these lines corresponds to a particular transition?

Scenario 2: The atom has two energy levels, and these are the only two transitions possible:

- Transition 1: from Level 1 to Level 2 (absorption) at 270 Nm
- Transition 2: from Level 2 back to Level 1 (emission or absorption) at 670 Nm

If the atom's structure allows only two energy levels, then the wavelengths are related to the energy difference between these levels, and the question becomes: what is the wavelength of the other line if only one is known?

Applying the Rydberg Formula

The Rydberg formula describes the wavelengths of spectral lines for hydrogen-like atoms:

$$\frac{1}{\lambda} = R \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

where:

- R is the Rydberg constant ($\sim 1.097 \times 10^7 \text{ m}^{-1}$),
- n_1 and n_2 are integers representing energy levels.

Note: For complex atoms, this formula is a simplified model, but it can give an approximation.

Assuming the two observed lines at 270 Nm and 670 Nm correspond to two transitions involving the same initial or final states, we can analyze their relation.

Calculating the Energy Difference and Inferring the Wavelength

The energy difference between the two states can be calculated from either of the wavelengths:

- For 270 Nm:

$$\Delta E_{270} = \frac{hc}{270 \times 10^{-9} \text{ m}} \approx 7.36 \times 10^{-19} \text{ J}$$

- For 670 Nm:

$$\Delta E_{670} = \frac{hc}{670 \times 10^{-9} \text{ m}} \approx 2.97 \times 10^{-19} \text{ J}$$

If these are transitions between the same two energy levels but in opposite directions, then the energy difference should be consistent, which suggests they are transitions involving different pairs of levels.

What Is The Wavelength of The Other Line?

If the question is asking, "Given the two absorption lines at 270 Nm and 670 Nm, what is the wavelength of the other line?" in the context of a simple atom with only these two lines, then:

- The two lines are at 270 Nm and 670 Nm.
- There are no other absorption lines, by assumption.
- Therefore, if one line's wavelength is known, the other is simply the remaining wavelength, i.e., 670 Nm if 270 Nm is given, or vice versa.

However, if the question is about calculating the complementary transition wavelength based on the energy levels, then more detailed quantum mechanical analysis would be required, involving the atom's specific energy level structure.

Practical Implications and Applications

Understanding these spectral lines isn't just an academic exercise. Such knowledge has real-world applications:

- Astrophysics: Identifying elements in stars by their spectral lines.
- Chemical Analysis: Detecting elements in a sample based on their absorption spectra.
- Lighting and Lasers: Designing light sources based on electronic transitions.

In particular, atoms with only a few spectral lines, like the hypothetical simple atom in this case, serve as models to simplify complex atomic behavior and test theoretical predictions.

Conclusion: The Wavelength of the Other Line

In summary, the atom in question exhibits two absorption lines at 270 Nm and 670 Nm. If these are the only two lines, then the question of "what is the wavelength of the other line" is straightforward: the other is at 670 Nm if 270 Nm is given, or vice versa.

More insight can be gained by analyzing the atom's energy levels and electronic structure, but based on the given data, the two absorption lines at these wavelengths are intrinsic to this atom's spectral signature. Recognizing these lines allows scientists to identify and understand the properties of this simple atom, illuminating the fundamental principles of atomic physics and spectroscopy.

In essence, the spectral lines at 270 Nm and 670 Nm encapsulate the atom's quantum nature, serving as a bridge between the microscopic world of

electrons and

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