



# Unveiling the Enigmatic World of Helium-1 and Helium-2: Properties, Behaviors, and Utilizations

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Received date: 21 May, 2024, Manuscript No. RRMT-24-136647;

Editor assigned date: 24 May, 2024, PreQC No. RRMT-24-136647 (PQ);

Reviewed date: 10 June, 2024, QC No. RRMT-24-136647;

Revised date: 10 March, 2025, Manuscript No. RRMT-24-136647 (R);

Published date: 17 March, 2025, DOI: 10.4172/Rmt.1000204

## Introduction

Helium, with its unique properties and behavior, exhibits distinct phases known as helium-1 and helium-2 under specific conditions of temperature and pressure. This manuscript delves into the concept of helium-1 and helium-2, elucidating their properties, behavior, and potential applications. Through a comprehensive review of literature and theoretical frameworks, this paper aims to provide a thorough understanding of the characteristics and significance of helium-1 and helium-2 in various scientific and technological domains.

Helium, the second lightest element in the periodic table, exhibits remarkable behavior under extreme conditions of low temperature and high pressure. At temperatures close to absolute zero, helium undergoes a phase transition, giving rise to two distinct phases known as helium-1 and helium-2. These phases exhibit unique properties, including superfluidity, which has intrigued scientists and engineers for decades. This manuscript explores the concept of helium-1 and helium-2, shedding light on their properties, behavior, and potential applications in various scientific and technological domains.

## Description

### Helium-1: Properties and behavior

Helium-1, also known as normal helium, is the phase of helium that exists at temperatures above the lambda point ( $\sim 2.17$  Kelvin). In this phase, helium behaves like a typical fluid, exhibiting viscosity and thermal conductivity. However, as the temperature approaches the lambda point, helium-1 undergoes a phase transition to helium-2, characterized by the onset of superfluidity. The properties of helium-1 are crucial for understanding the behavior of helium at low temperatures and serve as a reference point for studying superfluidity.

### Helium-2: Superfluidity and quantum behavior

Helium-2, also known as superfluid helium, is the phase of helium that exists at temperatures below the lambda point. In this phase, helium displays remarkable properties, including zero viscosity and infinite thermal conductivity, leading to phenomena such as

superfluidity. Superfluid helium exhibits unique quantum mechanical behavior, such as the formation of quantized vortices and the ability to flow without friction. These properties arise from the Bose-Einstein condensation of helium atoms at low temperatures, leading to the emergence of a macroscopic quantum state. The study of helium-2 has profound implications for understanding quantum mechanics and low-temperature physics.

## Experimental techniques and observations

Experimental techniques such as cryogenics and low-temperature physics are essential for studying helium-1 and helium-2. Techniques such as cooling helium to temperatures close to absolute zero using cryogenic systems and observing the behavior of superfluid helium using specialized apparatuses have provided valuable insights into the properties and behavior of these phases. Observations such as the quantized circulation of vortices in superfluid helium and the suppression of thermal conductivity at low temperatures have confirmed the existence of helium-2 and elucidated its unique characteristics.

## Applications of Helium-1 and Helium-2

Helium-1 and helium-2 find applications in various scientific and technological fields. In low-temperature physics, superfluid helium is used as a coolant for studying phenomena such as superconductivity and quantum phase transitions. In particle accelerators, helium-2 is utilized to cool superconducting magnets and maintain them at low temperatures. Helium-2 also finds applications in cryogenic storage and cooling systems for space exploration, medical imaging, and scientific research.

## Challenges and future directions

Despite significant advancements, challenges remain in the study and application of helium-1 and helium-2. Achieving and maintaining extremely low temperatures required for observing superfluid helium poses technical challenges. Additionally, further research is needed to explore the full range of applications of helium-1 and helium-2 in emerging fields such as quantum computing and quantum information science. Future directions may focus on developing novel experimental techniques and materials for manipulating and controlling the properties of helium at low temperatures.

## Conclusion

In conclusion, helium-1 and helium-2 represent fascinating phases of helium with unique properties and behavior. The study of these phases has led to significant advancements in understanding quantum mechanics, low-temperature physics, and superfluidity. With continued research and technological development, helium-1 and helium-2 hold promise for applications in various scientific and technological domains, paving the way for further exploration and innovation.

This manuscript provides a comprehensive overview of the concept of helium-1 and helium-2, offering insights into their properties, behavior, and potential applications in scientific and technological endeavors.

**Citation:** Pan C (2025) Unveiling the Enigmatic World of Helium-1 and Helium-2: Properties, Behaviors, and Utilizations. Res Rep Metals 9:1.