

Characteristics of Group VIII Elements in the Periodic Table and the Potential Uses and Applications

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Abstract

Group 8 elements, known as noble gases, hold a special place in the periodic table. Noble gases offer unique properties with applications in science, industry, and technology. By comprehensively understanding the characteristics of Group 8 elements, we not only appreciate their role in the periodic table but also recognize their significance in scientific research and industrial applications. This project sheds light on the unique properties of noble gases, highlighting their enduring importance in the world of chemistry. This research illustrates the physical and the chemical properties of the group 8 elements as well as the shorthand notations. The valency of each of the shorthand notation of the various elements considered were demonstrated in the investigation. The investigation highlights the emerging potential of Group 8 elements, classified as noble gases, and their relevance in chemical engineering, particularly in relation to industrial product formation.

Keywords: Characteristics, group VIII, elements, periodic, table

INTRODUCTION

Exploring the Noble Gases: Characteristics of Group 8 Elements in the Periodic Table

The periodic table, a renowned classification of chemical substances, provides significant insight into the essential components of matter [1]. Within this framework, Group 8 represents a distinct and intriguing set of elements known as the "noble gases". This group includes helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn). The elements in Group 8 are characterized by exceptional traits that differentiate them from other elements in the periodic table [2]. This discussion will examine the compelling features of noble gases, highlighting their stability, chemical inertness, and various applications [3].

THE QUEST FOR STABILITY: NOBLE GASES' ELECTRON CONFIGURATIONS

Central to the distinctiveness of noble gases is their remarkable stability. A closer examination of their atomic structure reveals the reasons behind this stability [4]. Atoms consist of protons, neutrons, and electrons, with electrons occupying different energy levels or shells surrounding the nucleus. Noble gases are unique because their outermost electron shells are entirely filled with electrons, granting them extraordinary stability [5].

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Moving through Group 8 from helium to radon, one observes progressively larger and more complex atoms, each with a full outer electron shell. Helium, the lightest noble gas, contains just two electrons in its singular shell, whereas radon, the heaviest, accommodates eight electrons in its outer shell. This adherence to the "octet rule", which states that eight valence electrons confer chemical stability, is notable. Elements typically seek to bond with others to fill their outer shells, but noble gases, having complete outer electron shells, remain detached from such interactions, earning them the designation of "inert" or "unreactive" [6].

Chemical Inertness: Noble Gases' Reluctance to Bond

The label "inert" may evoke notions of inactivity; however, in chemistry, it signifies a fascinating quality. Noble gases firmly resist the formation of chemical bonds with other elements. This contrasts sharply with most elements in the periodic table, which actively participate in chemical reactions to stabilize their electron configurations. In contrast, noble gases are satisfied with their current electron arrangements and do not seek to share or transfer electrons. Their non-reactivity exemplifies their chemical nobility [7].

Envision a grand ball where each dancer symbolizes an element, and their partners represent the electrons they wish to bond with. In this metaphorical setting, noble gases are akin to wallflowers, enjoying their own rhythm while gracefully declining invitations to dance. Their outer electron shells function like impenetrable barriers, unaffected by the allure of other elements [8].

PHYSICAL PROPERTIES: LOW BOILING AND MELTING POINTS

In addition to their chemical inertness, noble gases possess unique physical properties that enhance their distinction. Notably, they have remarkably low boiling and melting points compared to other elements. For example, helium holds the record for the lowest boiling and melting points of any element, remaining gaseous even at temperatures near absolute zero (-273.15°C or -459.67°F). This property makes helium invaluable for cryogenic applications, such as cooling superconducting materials and conducting scientific research at extremely low temperatures [9].

The trend of increasing boiling and melting points from helium to radon mirrors the growing size and complexity of these atoms. However, even the heaviest noble gases maintain relatively low boiling and melting points compared to many other elements.

COLORLESS, ODORLESS, AND NON-FLAMMABLE

Another noteworthy aspect of noble gases is their colorless, odorless, and non-flammable nature. In their elemental state, noble gases typically appear as transparent and odorless gases. This attribute renders them suitable for various applications where an absence of interference from gas properties is beneficial. For instance, neon, one of the most recognizable noble gases, is utilized to produce vibrant, illuminated signs due to its capacity to emit colorful light without altering its characteristics [10].

Furthermore, noble gases do not catch fire and do not support combustion. This trait enhances their safety in scenarios where flammable gases could pose risks, making them particularly valuable in lighting applications where safety is a primary concern.

THE PRACTICAL UTILITY OF NOBLE GASES

Despite their chemical inertness suggesting limited practicality, noble gases have a wide array of applications in scientific and industrial domains [11]. Here are some key uses:

- *Lighting:* Neon and argon are commonly used in various lighting technologies. Neon gas emits a striking red-orange glow when subjected to electrical discharge, making it a classic choice for neon signage. Argon is utilized in fluorescent and discharge lamps, serving as a stable filler gas.
- *Cryogenics:* The unique low-temperature properties of helium are applied in cryogenic contexts. It cools superconducting magnets in MRI machines, particle accelerators, and other

scientific instruments. Additionally, helium plays a crucial role in cryopreservation, preserving biological samples at ultra-low temperatures.

- *Medical Applications:* Although rare, xenon is employed in medical imaging and anesthesia. Xenon CT scans provide high-resolution imaging, and xenon gas can be utilized as an anesthetic agent due to its distinctive properties.
- *Radiological Tracers:* Krypton and xenon serve as radiological tracers in numerous scientific and industrial applications, helping to monitor fluid movement, investigate airflows, and detect leaks.
- *Radiation Shielding:* Due to its dense nature, xenon is employed in radiation shielding applications to protect against ionizing radiation in nuclear power facilities and medical settings.

The Enigmatic Radon: A Radioactive Noble Gas

Among noble gases, radon is a peculiar exception, being the only radioactive noble gas. It naturally occurs as a decay product of uranium and thorium. Radon poses a distinct health risk when it accumulates in poorly ventilated areas, such as basements and underground spaces. Its radioactive decay products can emit alpha and beta particles as well as gamma rays, which can be harmful when inhaled [12].

Consequently, testing and mitigation for radon are essential in regions where high radon levels are prevalent. These measures aim to reduce exposure to radon and ensure good indoor air quality.

Conclusion: The Noble Legacy of Group 8 Elements

In summary, Group 8 of the periodic table, consisting of noble gases, provides an intriguing insight into the world of chemistry. Their stability, chemical inertness, and varied applications establish them as a distinct and valuable group of elements. From helium's role in cryogenics to neon's vibrant presence in signage and xenon's applications in medical imaging, these elements have made a lasting impact on both science and industry [13, 14].

Ultimately, their inherent nature as "nobles" among elements is what truly distinguishes them, characterized by their completely filled outer electron shells.

MATERIALS AND METHODS

To investigate and understand the characteristics of Group 8 elements (noble gases) in the periodic table, a combination of theoretical research and experimental procedures was employed. The study aimed to elucidate the unique properties and behaviors of these elements. It is essential to recognize the limitations of this theoretical study, including the lack of real experimental data. Additionally, noble gases' inherent inertness may pose challenges in observing significant chemical reactions.

Research Methodology

We will conduct an extensive literature review of scholarly articles, textbooks, and online resources to gather information on the electron structure of Group 8 elements, their properties, and their chemical behavior. This review will serve as the foundation for our discussion.

LITERATURE REVIEW

A comprehensive review of scientific literature was conducted to establish a strong theoretical foundation in respect to the topic. Key aspects covered include the physical properties, chemical behavior, and historical significance of noble gases.

Practical Applications

To show the real-world significance of the noble gases, we will explore practical applications across various fields, including industry, technology, and medicine. Facts and examples will be drawn from reliable sources to showcase the utility of noble gases.

Throughout our exploration of this topic, we will ensure proper citations and references for all data sources and scholarly materials consulted to give credit to whom honor is due.

RESULTS AND DISCUSSION

The allure of noble gases, classified as Group 8 elements in the periodic table, stems from their distinctive properties and significant contributions to science and technology:

Helium (He)

- Chemical Symbol and Atomic Number
 - *Symbol:* He
 - *Atomic number:* 2
 - Helium ranks as the second lightest element, following hydrogen.
 - Noble Gas Classification
 - Helium is categorized as a noble gas (Group 18 or Group VIII A), known for its minimal reactivity linked to stable electron configurations.
 - Atomic Structure
 - With two protons, two neutrons, and two electrons, helium has the second simplest atomic structure after hydrogen, enhancing its stability.
 - Electron Configuration
 - Helium's electron configuration is $1s^2$, fully occupying its single energy level.
 - Inert Nature
 - Due to its fully filled electron configuration, helium is chemically inert and does not easily form compounds.
 - Low Density
 - Being less dense than air, helium is buoyant, leading to its use in balloons and airships for lift.
 - Boiling and Melting Points
 - Helium possesses extremely low boiling and melting points at -268.9°C (-452°F) and -272.2°C (-457.9°F), respectively, making it the element with the lowest temperatures.
 - Thermal Conductivity
 - It demonstrates exceptional thermal conductivity, making it valuable for cooling purposes in low-temperature physics experiments.
 - Cryogenic Applications
 - Helium is essential in cryogenics, particularly for cooling superconducting magnets in MRI machines and particle accelerators.
 - Isotopes
 - *Helium exists as two stable isotopes:* helium-3 (two protons, one neutron) and helium-4 (two protons, two neutrons), with helium-4 being the more prevalent isotope.
 - Earthly Abundance
 - Helium is relatively rare on Earth's surface and is primarily extracted from natural gas deposits, where it is produced through natural radioactive decay.
 - Cosmic Abundance
 - It is the second most abundant element in the universe, generated through nuclear fusion in stars, including the sun.
 - Physical Properties
 - Helium is colorless, odorless, and tasteless at ambient conditions, making detection without specialized equipment challenging.
 - Voice Alteration
 - Inhaling helium temporarily raises the pitch of a person's voice due to its lower density compared to air, affecting the resonance of vocal cords.
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In summary, helium is an inert, lightweight, non-flammable gas with distinctive physical attributes. Its low boiling and melting points, high thermal conductivity, and cosmic abundance render it essential across various scientific, industrial, and recreational fields, from cooling superconductors to inflating balloons. Despite its scarcity on Earth, helium is pivotal in contemporary technology and research.

Neon (Ne)

- Chemical Symbol and Atomic Number
 - *Symbol:* Ne
 - *Atomic number:* 10
 - Neon is the tenth element in the periodic table.
- Noble Gas Classification
 - As a noble gas (Group 18 or Group VIII A), neon is characterized by low reactivity due to its stable electron configuration.
- Electron Configuration
 - Neon possesses a stable electron configuration of $1s^2 2s^2 2p^6$, indicating a full valence shell with eight electrons, which enhances its stability and inertness.
- Color and Appearance
 - Neon is a colorless, odorless, and tasteless gas at room temperature, emitting a distinct reddish-orange glow when electrically excited, leading to its use in neon signs.
- Density
 - Lighter than air, neon escapes the atmosphere easily if not contained.
- Abundance
 - Neon is relatively scarce in Earth's atmosphere, comprising about 18 ppm, and is typically extracted from the atmosphere through the fractional distillation of liquid air.
- Etymology
 - The name "neon" originates from the Greek word "neos", meaning "new gas", reflecting its relatively recent discovery compared to other noble gases.
- Inert Nature
 - Neon is chemically inert, exhibiting a stable full valence shell that prevents it from forming compounds.
- Applications
 - Notably, neon is used in signs, lasers, cryogenic applications, and high-energy particle detection.
- Natural Abundance
 - Primarily created through nucleosynthesis in massive stars, neon is released into space during supernova events.
- Isotopes
 - Neon has three stable isotopes: neon-20, neon-21, and neon-22, with neon-20 being the most abundant.
- Noble Gas Behavior
 - Neon behaves typically as a noble gas, showing resistance to chemical reactions and a preference for existing as single atoms.
- Safety Precautions
 - At standard atmospheric concentrations, neon presents no significant health risks. However, it can displace oxygen in confined spaces, necessitating careful handling.

In summary, neon is a noble gas characterized by a stable electron configuration, inert nature, and a distinctive glow when electrically excited. Although relatively rare on Earth, its applications extend to lighting, lasers, and scientific research, contributing to technological advancements and artistic expressions. Additionally, its formation from stellar processes enhances its relevance in astrophysics and cosmology.

Argon (Ar)

- Chemical Symbol and Atomic Number
 - *Symbol:* Ar
 - *Atomic number:* 18
 - Argon is the 18th element in the periodic table.
- Noble Gas Classification
 - Argon is classified as a noble gas (Group 18 or Group VIII A), recognized for its low reactivity due to stable electron configurations.
- Electron Configuration
 - With a stable electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6$, argon has a full valence shell of eight electrons, ensuring its stability and inertness.
- Color and Appearance
 - Argon is a colorless, odorless, and tasteless gas at room temperature, non-toxic and non-flammable.
- Density
 - Heavier than air, argon is often utilized as a shielding gas in industrial applications like welding.
- Abundance
 - Making up about 0.93% of the Earth's atmosphere by volume, argon is the third most prevalent gas, following nitrogen and oxygen.
- Etymology
 - The term "argon" derives from the Greek word "argos", which means "lazy" or "inactive", reflecting its lack of reactivity.
- Inert Nature
 - Argon is chemically inert and does not easily form compounds, maintaining a stable full valence shell.
- Applications
 - Argon is used in various industrial processes, including welding, semiconductor production, lighting applications, and as a carrier gas in analytical instruments.
- Isotopes
 - Argon has three naturally occurring isotopes: argon-36, argon-38, and argon-40, with argon-40 being the most prevalent, utilized in radiometric dating techniques.
- Noble Gas Behavior
 - It demonstrates typical noble gas characteristics, such as resistance to chemical reactions and existing as single atoms.
- Safety Precautions
 - Argon gas is considered safe at normal atmospheric levels but can displace oxygen in confined spaces, posing a potential asphyxiation risk.
- Discovery
 - Discovered in 1894 by Lord Rayleigh and Sir William Ramsay, argon was identified during studies on air composition.

In summary, argon is a noble gas distinguished by its stable electron configuration, inert nature, and significant presence in the Earth's atmosphere. It is integral to various industrial applications, including welding and semiconductor manufacturing, as well as in scientific research and radiometric dating. Its discovery was pivotal in enhancing our understanding of the Earth's atmospheric composition.

Krypton (Kr)

- Chemical Symbol and Atomic Number
 - *Symbol:* Kr

- *Atomic number:* 36
- Krypton is the 36th element in the periodic table.
- Noble Gas Classification
 - Krypton is classified as a noble gas (Group 18 or Group VIII A), known for its low reactivity due to stable electron configurations.
- Electron Configuration
 - Krypton has a stable electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$, resulting in a full valence shell of eight electrons, ensuring stability and inertness.
- Color and Appearance
 - Krypton is a colorless, odorless, and tasteless gas at room temperature, non-toxic and non-flammable.
- Density
 - Being denser than air, krypton is often used as a filling gas in energy-efficient windows for improved insulation.
- Abundance
 - Krypton is a rare noble gas in the atmosphere, constituting about 1 ppm in volume, obtained as a byproduct of liquid air production.
- Etymology
 - The name "krypton" is derived from the Greek word "kryptos", meaning "hidden" or "concealed", reflecting its rarity and unreactive nature.
- Inert Nature
 - Krypton is chemically inert and does not readily combine with other elements, maintaining a stable configuration.
- Applications
 - It has specific applications, including use in high-intensity discharge lamps for photography and film, as well as in lasers for medical procedures.
- Isotopes
 - Krypton has several naturally occurring isotopes, with krypton-84 and krypton-86 being the most abundant, while some isotopes, like krypton-85, are radioactive.
- Noble Gas Behavior
 - Krypton exhibits typical noble gas behavior, including resistance to chemical reactions and preference for existing as single atoms.
- Safety Precautions
 - At normal atmospheric concentrations, krypton is not hazardous, but it can displace oxygen in enclosed environments, necessitating caution.
- Discovery
 - Discovered in 1898 by Sir William Ramsay and Morris Travers, krypton was identified in the residue left after distillation of liquid air.

In summary, krypton is a noble gas with unique attributes, including a stable electron configuration, inert nature, and rarity in the atmosphere. Its specialized applications in lighting, laser technology, and industrial gauges make it valuable in specific fields. Krypton's discovery enhanced our understanding of the Earth's atmospheric composition and the classification of noble gases.

Xenon (Xe)

- Chemical Symbol and Atomic Number
 - *Symbol:* Xe
 - *Atomic number:* 54
 - Xenon is the 54th element in the periodic table.
- Noble Gas Classification
 - Xenon is classified as a noble gas (Group 18 or Group VIII A), characterized by low reactivity due to stable electron configurations.

- Electron Configuration
 - Xenon has an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$, indicating a full valence shell of eight electrons, ensuring its stability and inertness.
- Color and Appearance
 - Xenon is a colorless, odorless, and tasteless gas at room temperature, non-toxic and non-flammable.
- Density
 - Heavier than air, xenon is often used as a filling gas in energy-efficient windows to enhance insulation.
- Abundance
 - Xenon is a rare noble gas in the atmosphere, constituting about 0.000009% by volume and is obtained as a byproduct of liquid air production.
- Etymology
 - The name "xenon" comes from the Greek word "xenos", meaning "stranger" or "foreigner", reflecting its status as an unusual atmospheric component.
- Inert Nature
 - Like other noble gases, xenon is chemically inert and does not readily form compounds, maintaining a stable valence shell.
- Applications
 - Xenon finds uses in high-intensity discharge lamps, lasers, xenon flash lamps for photography, and as a coolant in nuclear reactors and spacecraft propulsion systems.
- Isotopes
 - It has several naturally occurring isotopes, with xenon-129 and xenon-131 being the most abundant, while some isotopes are radioactive.
- Noble Gas Behavior
 - Xenon displays typical noble gas behavior, including resistance to chemical reactions and a tendency to exist as single atoms.
- Safety Precautions
 - At normal atmospheric concentrations, xenon poses no significant health risks; however, it can displace oxygen in confined spaces, requiring careful handling.
- Discovery
 - Discovered in 1898 by Sir William Ramsay and Morris Travers, xenon's identification arose from studies on the composition of the residue from distilled liquid air.

In summary, xenon is a noble gas marked by its stable electron configuration, inertness, and rarity in the atmosphere. It is utilized in specialized applications across lighting, laser technology, and space propulsion, underscoring its importance in various industries. Xenon's discovery was a significant advancement in our understanding of the Earth's atmospheric composition and the classification of noble gases.

Radon (Rn)

- Chemical Symbol and Atomic Number
 - *Symbol:* Rn
 - *Atomic number:* 86
 - Radon is the 86th element in the periodic table.
- Noble Gas Classification
 - Radon is classified as a noble gas (Group 18 or Group VIII A), recognized for its low reactivity due to stable electron configurations.
- Electron Configuration
 - Radon has a stable electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6$, resulting in a full valence shell of eight electrons, ensuring its stability and inertness.

- Color and Appearance
 - Radon is a colorless, odorless, and tasteless gas at room temperature, non-toxic and non-flammable.
- Density
 - Being denser than air, radon can accumulate in poorly ventilated areas.
- Radioactive Nature
 - Unlike other noble gases, radon is radioactive, emitting alpha particles as it decays, which is a defining characteristic.
- Abundance
 - Radon is a rare noble gas in the atmosphere, present only in trace amounts, primarily sourced from the decay of uranium and thorium in the Earth's crust.
- Health Concerns
 - Radon poses health risks when it accumulates indoors, as inhalation of the gas and its decay products can elevate lung cancer risk, making it a significant indoor air pollutant.
- Etymology
 - The name "radon" is derived from "radium emanation", as it was initially identified as a radioactive gas emitted by radium.
- Inert Nature (Chemically)
 - Radon exhibits chemical inertness similar to other noble gases, not readily forming compounds due to its full valence shell.
- Uses
 - Limited practical applications exist for radon, primarily due to its radioactivity, though it has some medical uses related to its alpha-particle radiation.
- Isotopes
 - Several isotopes of radon exist, with radon-222 (Rn-222) being the most common and linked to health risks.
- Noble Gas Behavior
 - Radon displays typical noble gas behavior, including resistance to chemical reactions and a tendency to exist as single atoms.
- Safety Precautions
 - Due to its radioactivity, radon gas poses health risks when it accumulates indoors; testing for radon levels and implementing mitigation measures are crucial for safety.
- Discovery
 - Radon was discovered in 1900 by Friedrich Ernst Dorn during his research on radium's radioactive decay.

In summary, radon is a distinctive noble gas characterized by its radioactivity, inertness, and scarcity in the atmosphere. Its radioactive properties raise concerns regarding indoor air quality, particularly concerning lung cancer risks. Radon's unique attributes underline its significance in discussions of human health and environmental safety.

Each of these noble gases possesses distinct properties and applications, playing vital roles across various scientific, industrial, and technological fields.

CONCLUSION

In the study of the periodic table, Group 8, recognized as the noble gases, exemplifies the intriguing and distinctive properties that chemical elements can exhibit. This summary highlights the essential nature and importance of the traits associated with these noble gases, which include helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn).

The most defining feature of noble gases is their natural inertness. Among them, helium, being the lightest, remains chemically stable under typical conditions, making it invaluable in applications such

as cryogenics and high-altitude research. Neon is renowned for its unique luminescence when electrified, a characteristic that has significantly influenced the realms of signage and artistic expression. Argon, which is plentiful in the Earth's atmosphere, plays a crucial role in safeguarding welding operations and various industrial processes.

Krypton and xenon, notable for their exceptional spectral emissions and stable light outputs, have made significant contributions to high-powered lasers and energy-efficient lighting, respectively. Their roles have transformed both technological advancements and everyday experiences. Despite its radioactive properties and associated health concerns, radon enriches our comprehension of Earth's geology and the concealed processes occurring beneath our surface.

In conclusion, the properties of Group 8 elements, the noble gases, illustrate the remarkable variety found within the periodic table. From the enchanting glow of neon signage to the accuracy of medical imaging utilizing xenon, these elements narrate a tale of scientific marvel and practical application. Their allure is not only in their characteristics but also in the numerous ways they enhance our lives and broaden our understanding of the natural environment.

As we conclude this exploration, it is clear that the periodic table is a rich collection of elements, each possessing unique traits and contributions. The noble gases of Group 8 continue to kindle curiosity, spur innovation, and foster discovery, reminding us of the limitless beauty and potential that lie within the field of chemistry. This concluding section encapsulates the importance of the characteristics of Group 8 elements and their influence on science and technology.

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