

# Name The Element In The Third Period Of The Periodic Table With 5 Valence Electrons.

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Understanding the elements of the periodic table is fundamental to chemistry. Among the various classifications and properties, the number of valence electrons plays a crucial role in determining an element's chemical behavior and reactivity. In this article, we will explore the element in the third period of the periodic table that possesses five valence electrons, delve into its characteristics, and examine its significance in chemistry and industry.

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## Introduction to the Periodic Table and Valence Electrons

The periodic table is a systematic arrangement of chemical elements based on their atomic number, electron configurations, and recurring chemical properties. It is structured into periods (rows) and groups (columns).

- Periods: Horizontal rows that indicate the number of electron shells.
- Groups: Vertical columns that contain elements with similar valence electron configurations and chemical properties.

Valence electrons are the electrons in the outermost shell of an atom and are responsible for chemical bonding and reactivity. Elements with the same number of valence electrons tend to exhibit similar chemical behaviors, which is why understanding valence electrons is vital in predicting how elements interact.

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## The Element in the Third Period with 5 Valence Electrons

In the third period of the periodic table, the elements are arranged from sodium (Na) to argon (Ar). To identify the element with five valence electrons, we examine their electron configurations:

| Element | Atomic Number | Electron Configuration | Valence Electrons |  |
|---------|---------------|------------------------|-------------------|--|
|---------|---------------|------------------------|-------------------|--|

|  |                |  |       |  |                                      |  |       |  |
|--|----------------|--|-------|--|--------------------------------------|--|-------|--|
|  | -----          |  | ----- |  | -----                                |  | ----- |  |
|  | Sodium (Na)    |  | 11    |  | [Ne] 3s <sup>1</sup>                 |  | 1     |  |
|  | Magnesium (Mg) |  | 12    |  | [Ne] 3s <sup>2</sup>                 |  | 2     |  |
|  | Aluminum (Al)  |  | 13    |  | [Ne] 3s <sup>2</sup> 3p <sup>1</sup> |  | 3     |  |
|  | Silicon (Si)   |  | 14    |  | [Ne] 3s <sup>2</sup> 3p <sup>2</sup> |  | 4     |  |
|  | Phosphorus (P) |  | 15    |  | [Ne] 3s <sup>2</sup> 3p <sup>3</sup> |  | 5     |  |
|  | Sulfur (S)     |  | 16    |  | [Ne] 3s <sup>2</sup> 3p <sup>4</sup> |  | 6     |  |
|  | Chlorine (Cl)  |  | 17    |  | [Ne] 3s <sup>2</sup> 3p <sup>5</sup> |  | 7     |  |
|  | Argon (Ar)     |  | 18    |  | [Ne] 3s <sup>2</sup> 3p <sup>6</sup> |  | 8     |  |

From the table above, phosphorus (P) is the element in the third period that has five valence electrons.

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## Phosphorus: The Element with 5 Valence Electrons

### Basic Properties of Phosphorus

- Atomic Number: 15
- Atomic Weight: 30.97 g/mol
- Symbol: P
- State at Room Temperature: Solid
- Appearance: Usually exists in several allotropes, including white, red, and black phosphorus.

### Electron Configuration

Phosphorus has the electron configuration: [Ne] 3s<sup>2</sup> 3p<sup>3</sup>, indicating five electrons in its outermost shell, which are responsible for its chemical bonding behavior.

### Physical and Chemical Characteristics

- Reactivity: Phosphorus is reactive, especially with oxygen and halogens.
- Allotropes: Exists in several forms, with white phosphorus being highly reactive and red phosphorus being more stable.
- Solubility: Slightly soluble in acids but insoluble in water.
- Toxicity: White phosphorus is highly toxic and flammable.

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## Roles and Uses of Phosphorus

Phosphorus plays a vital role in various biological, industrial, and

agricultural applications:

### Biological Significance

- Essential Element: Phosphorus is crucial for life as it forms part of DNA, RNA, ATP, and cell membranes.
- Bone and Teeth Formation: It contributes to the strength and structure of bones and teeth.

### Industrial and Agricultural Uses

- Fertilizers: The most significant use of phosphorus is in manufacturing phosphate fertilizers, which support plant growth.
- Steel Production: Used as a deoxidizer in steel manufacturing.
- Pesticides and Flame Retardants: Incorporated into various chemical formulations for pest control and fire resistance.

### Other Applications

- Matchstick Production: White phosphorus was historically used in matches, although safer alternatives are now common.
- Semiconductors: P-type doping in semiconductors involves phosphorus.

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## Chemical Behavior of Phosphorus

### Valence and Bonding

- Valence Electrons: 5, which allows phosphorus to form various covalent bonds.
- Common Oxidation States: -3, +3, +5.
- The +5 oxidation state is the most common in oxidation compounds like phosphates.
- The -3 state occurs when phosphorus forms phosphides.

### Bond Formation

Phosphorus tends to form covalent bonds due to its non-metallic nature. It can form molecules like  $\text{PCl}_5$ ,  $\text{P}_4$ , and various phosphates.

### Reactivity with Other Elements

- Reacts readily with oxygen to form phosphorus pentoxide ( $\text{P}_4\text{O}_{10}$ ).
- Reacts with halogens to form phosphorus halides such as phosphorus trifluoride ( $\text{PF}_3$ ) and phosphorus pentachloride ( $\text{PCl}_5$ ).

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# Environmental and Safety Considerations

While phosphorus is essential for life and industry, it requires careful handling due to its toxic forms, especially white phosphorus. Environmental concerns include:

- **Water Pollution:** Excess phosphorus from fertilizers can lead to eutrophication of water bodies.
- **Toxicity:** White phosphorus is highly toxic and can cause severe health issues if mishandled.

Proper disposal and environmentally friendly practices are critical when dealing with phosphorus compounds.

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## Summary

In conclusion, the element in the third period of the periodic table with five valence electrons is phosphorus (P). Its unique electron configuration makes it a versatile element with significant biological importance and industrial applications. Understanding its properties, uses, and safety measures is essential for chemists, biologists, and industry professionals alike.

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## Frequently Asked Questions (FAQs)

- **What is the significance of valence electrons?** Valence electrons determine how an element reacts chemically and bonds with other elements.
- **Why is phosphorus important?** It is vital for biological molecules like DNA and ATP and is extensively used in fertilizers and industrial processes.
- **What are the common forms of phosphorus?** White, red, and black phosphorus, each with different properties and uses.
- **Is phosphorus safe to handle?** Certain forms like white phosphorus are highly toxic and flammable, requiring careful handling and safety precautions.

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By understanding the characteristics of phosphorus, we gain insights into its role in nature and industry, emphasizing its importance in the periodic table and beyond.

## **Frequently Asked Questions**

### **Which element in the third period of the periodic table has 5 valence electrons?**

Phosphorus is the element in the third period with 5 valence electrons.

### **What are the properties of the element in the third period with 5 valence electrons?**

The element, phosphorus, is a non-metal with five valence electrons, typically forming  $P^{3-}$  ions and exhibiting allotropy.

### **How does the number of valence electrons affect the chemical behavior of phosphorus?**

Having five valence electrons makes phosphorus tend to gain three electrons or share electrons in covalent bonds, influencing its reactivity and compound formation.

### **In which group is the element with 5 valence electrons in the third period located?**

It is located in Group 15 (Group V) of the periodic table.

### **What is the atomic number of the element in the third period with 5 valence electrons?**

The atomic number of phosphorus is 15.

### **What are some common compounds of phosphorus in the third period?**

Common compounds include phosphorus pentachloride ( $PCl_5$ ), phosphoric acid ( $H_3PO_4$ ), and various phosphates.

## **Why is phosphorus considered a vital element for living organisms?**

Phosphorus is essential for DNA, RNA, ATP, and bone mineralization, making it crucial for biological functions.

## **How does the position of phosphorus in the periodic table influence its chemical reactivity?**

Its position in Group 15 and the presence of five valence electrons make phosphorus reactive, especially in forming covalent bonds and oxidation states.

## **What are the physical states of phosphorus at room temperature?**

Phosphorus exists in several allotropes, including white (or yellow), red, and black phosphorus, with white phosphorus being a solid at room temperature.

## **Additional Resources**

Element with 5 Valence Electrons in the Third Period of the Periodic Table

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## **Introduction: Unlocking the Element's Identity and Significance**

In the expansive universe of chemistry, understanding the periodic table is akin to deciphering the universe's blueprint. Each element within this chart offers a unique set of properties, behaviors, and applications that influence countless industries and scientific pursuits. Among these elements, some stand out due to their electron configurations, especially those with specific valence electrons that define their chemical reactivity and bonding capabilities.

Today, we turn our focus to an intriguing element located in the third period of the periodic table, distinguished by having five valence electrons. This particular element's position, electron configuration, and properties make it a subject of interest for chemists, educators, and industry professionals alike. The element in question is Phosphorus (P).

In this detailed review, we will explore the element's placement, electron configuration, physical and chemical properties, common applications, and its

significance in both natural and industrial contexts.

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## Locating the Element in the Periodic Table

### Position in the Periodic Table

Phosphorus is situated in Period 3, within Group 15 of the periodic table, also known as the Nitrogen group or pnictogens. Its atomic number is 15, which indicates it has 15 protons in its nucleus and, when neutral, 15 electrons.

The periodic table's structure places phosphorus in the third period, meaning it has three electron shells. It is the second element in Group 15, following nitrogen (atomic number 7) and preceding arsenic (atomic number 33).

### Significance of Its Position

This placement influences phosphorus's fundamental properties:

- Valence Electrons: Because it's in Group 15, phosphorus has five valence electrons in its outermost shell (third shell).
- Chemical Behavior: The five valence electrons allow phosphorus to form a variety of compounds, often exhibiting multiple oxidation states, most commonly -3, +3, and +5.
- Physical Properties: Its location also impacts its phase at room temperature, allotropes, and reactivity.

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## Electron Configuration and Valence Electrons

### Electron Configuration of Phosphorus

The electron configuration describes the distribution of electrons in an atom's shells and subshells:

- Full configuration:  $1s^2 2s^2 2p^6 3s^2 3p^3$

Breaking it down:

- $1s^2$ : 2 electrons in the first shell
- $2s^2 2p^6$ : 8 electrons in the second shell
- $3s^2 3p^3$ : 5 electrons in the third shell (valence shell)

This configuration confirms that phosphorus has five electrons in its outermost shell, which are responsible for its bonding behavior.

## Valence Electrons: The Key to Reactivity

Valence electrons dictate how an element interacts with others, forming bonds and compounds. For phosphorus:

- Number of Valence Electrons: 5
- Implications:
  - Ability to form up to five covalent bonds.
  - Exhibits multiple oxidation states (+3 and +5 being the most common).
  - Tends to act as a non-metal with characteristic covalent bonding patterns.

This electron configuration is essential for understanding phosphorus's behavior in various chemical reactions, especially organic and inorganic chemistry.

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## Physical Properties of Phosphorus

Understanding phosphorus's physical traits provides insight into its applications and handling.

## Allotropes of Phosphorus

Phosphorus exists in several allotropes, each with distinct physical characteristics:

- White (or Yellow) Phosphorus:
  - Appearance: waxy, wax-like, translucent solid
  - Reactivity: highly reactive and flammable
  - Uses: in chemical synthesis, matches, and incendiary devices
- Red Phosphorus:

- Appearance: amorphous, powdery, dull red
- Reactivity: less reactive than white phosphorus
- Uses: safety matches, fireworks, and pesticides
  
- Black Phosphorus:
- Appearance: shiny, layered, black solid
- Reactivity: relatively stable
- Uses: electronic devices, semiconductors
  
- Violet (Hittorf's) Phosphorus:
- Less common, deep violet color
- Used mainly in research

## Physical State and Density

- At room temperature, white phosphorus is a solid with a waxy texture.
- Density varies among allotropes:
- White phosphorus: approximately  $1.82 \text{ g/cm}^3$
- Red phosphorus: about  $2.34 \text{ g/cm}^3$
- Black phosphorus: roughly  $2.69 \text{ g/cm}^3$

## Other Physical Properties

- Melting Point: White phosphorus melts at approximately  $44.2^\circ\text{C}$
- Boiling Point: Around  $280^\circ\text{C}$
- Solubility:
- Insoluble in water
- Soluble in carbon disulfide ( $\text{CS}_2$ )

Understanding these properties is vital for safe handling and industrial processing.

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## Chemical Properties and Reactivity

### Bonding and Compound Formation

Phosphorus's five valence electrons allow it to:

- Form covalent compounds with non-metals
- Exhibit multiple oxidation states, notably +3 and +5
- Participate in allotropes that influence its reactivity

## Common Reactions

- Oxidation:
  - Phosphorus can be oxidized to produce phosphorus pentoxide ( $P_4O_{10}$ ), a potent desiccant.
- Reduction:
  - Phosphorus compounds can be reduced to elemental phosphorus.
- Combustion:
  - White phosphorus readily ignites in air, producing phosphorus pentoxide.
- Formation of Phosphates:
  - Reacts with acids to form phosphate salts, essential in biological systems.

## Reactivity Trends

- White phosphorus is highly reactive and must be stored under water to prevent oxidation.
- Red phosphorus is less reactive and more stable, making it safer for handling.
- Black phosphorus is the most stable allotrope, with properties akin to graphite.

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## Applications and Significance

### Industrial and Biological Uses

Phosphorus's applications span multiple sectors:

- Agriculture:
  - Major component of fertilizers (e.g., phosphate fertilizers)
- Chemical Industry:
  - Production of phosphoric acid, used in food and beverages
  - Manufacturing of detergents and flame retardants
- Electronics:
  - Black phosphorus's semiconducting properties are promising for next-generation electronics, including transistors and photodetectors
- Biology and Medicine:
  - Phosphates are essential in DNA, RNA, ATP, and bones
  - Used in medical imaging and as nutritional supplements

## Environmental Significance

Phosphorus, being a key nutrient, influences ecosystems profoundly:

- Excess phosphorus from runoff causes eutrophication in water bodies, leading to algae blooms and oxygen depletion.
- Sustainable management of phosphorus resources is critical due to its finite nature and importance in agriculture.

## Safety and Handling

- White phosphorus is pyrophoric and must be stored underwater.
- Red phosphorus is safer but still requires careful handling.
- Proper storage and disposal procedures are essential to prevent environmental contamination and health hazards.

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## Summary: The Expert's Perspective

Phosphorus, with its position in the third period and five valence electrons, exemplifies a versatile element that bridges inorganic and organic chemistry. Its electron configuration ( $1s^2 2s^2 2p^6 3s^2 3p^3$ ) underpins its ability to form a wide array of compounds, from vital biological molecules to industrial chemicals.

Its allotropes demonstrate the element's adaptability, with each form suited to different applications based on stability and reactivity. The element's importance in life sciences, agriculture, and electronics underscores its significance beyond the laboratory.

In the context of periodic trends, phosphorus's properties reflect its placement in the p-block, its moderate metallic character, and its capacity for multiple oxidation states. Its reactive nature, especially in white phosphorus form, necessitates careful handling but offers immense utility.

Final thoughts: As an element in the third period with five valence electrons, phosphorus continues to be a cornerstone of scientific innovation, environmental sustainability, and biological systems. Its multifaceted nature makes it a fascinating subject for ongoing research and application development.

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In conclusion, identifying and understanding the element with five valence electrons in the third period—phosphorus—reveals a rich tapestry of chemical

behavior, practical applications, and biological importance. From its electron configuration to its allotropes and industrial uses, phosphorus exemplifies the profound influence that atomic structure exerts on an element's role in our world.

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