OXYGEN DISCOVERY

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Abstract: Oxygen, a non-metallic element classified within Group 16 (VIa) of the periodic table, is a colorless, odorless gas vital to sustaining life. Highly esteemed for its involvement in animal respiration and plant photosynthesis, oxygen engages with various elements, forming diverse compounds. It facilitates combustion, emitting heat and light. Its paramount combination, water, underscores its significance. Joseph Priestley, an English chemist and controversial theologian of the 18th century, made the groundbreaking discovery of oxygen. He observed oxygen's role in sustaining life and combustion through tedious gas experiments, ultimately challenging the long-standing belief in air as an unalterable elemental substance. Key facts underscore the significance of oxygen: its presence in Earth's atmosphere at about 21%, the presence of ozone crucial for shielding Earth from harmful radiation, and its role as the third most abundant element in the universe. Additionally, while essential for life, excessive inhalation of pure oxygen can be harmful, leading to oxygen toxicity. Furthermore, oxygen's presence in water ensures the sustainability of oceans, a cornerstone for supporting life.

Keywords: Oxygen; Joseph Priestley; Chemical Element

1. Introduction

Oxygen (O) is a nonmetal chemical element of the periodic table's Group 16 (VIa, or the oxygen group). Oxygen is a colorless, odorless, tasteless gas essential to living organisms. Being taken up by humans and animals, which convert it to carbon dioxide, plants, in turn, utilize carbon dioxide as a carbon source and return the oxygen to the atmosphere. Oxygen readily combines with virtually any other element, forming compounds through various reactions, including displacement reactions that extract features from their existing combinations. Often, these processes generate heat and light, leading to what we commonly know as combustions. Water stands out as oxygen's most crucial compound among its numerous compounds.

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2. Discovery of oxygen

Around 2,500 years ago, ancient Greek philosophers recognized air, earth, fire, and water, as fundamental elements shaping creation. Although this concept may appear quaint by today's standards, it held considerable merit, enduring until the late 18th century. The persistence of this idea remained largely unchallenged until the emergence of Joseph Priestley, an English chemist and unconventional theologian known for his independent thinking (see Figure 1) [1].

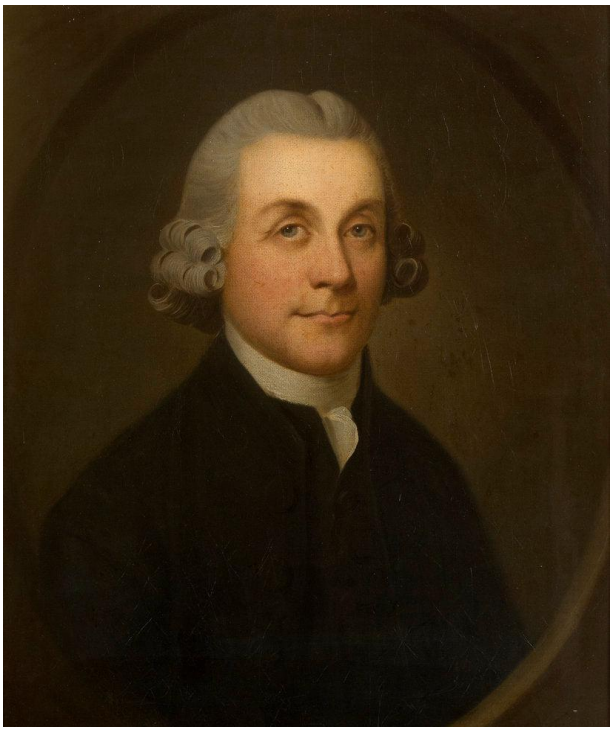

Figure 1. Portrait of Joseph Priestley

Priestley (1733 to 1804) made significant contributions to science and philosophy. Known for inventing carbonated water and the rubber eraser, he also discovered numerous essential chemical compounds and authored a critical paper on electricity. However, his unconventional religious views and advocacy for the American and French revolutions led to widespread criticism, forcing him to leave England in 1794. He sought refuge in Pennsylvania, where he continued his research until his passing [2].

Priestley systematically examined diverse "airs" using the prevalent apparatus of his time—an inverted container on a raised platform, which could trap gasses from experiments below. Submerging the container in water or mercury could seal it for further analysis. Additional tests within the container gauged a gas's ability to sustain a flame or support life. Priestley observed a critical phenomenon in these experiments: a flame extinguished, and a mouse suffocated in the sealed jar. Intriguingly, introducing a sunlit green plant into the pot "refreshed" the air, allowing the flame to persist and the mouse to respire. Priestley theorized that the potential harm caused by numerous animals might, in part, be mitigated by the actions of the vegetable world. This led him to the groundbreaking insight that plants release oxygen into the air—a phenomenon we now recognize as photosynthesis. Priestley is most renowned for discovering oxygen, the vital component of Earth's atmosphere. This breakthrough revealed a fundamental truth about our environment. It challenged a long-

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standing belief entrenched in scientific thought for 23 centuries: the notion that air was a singular, immutable substance, impervious to change. As Priestley noted, few concepts had such a profound and enduring grip on the collective understanding of the natural world.

On August 1st, 1774, Priestley conducted a groundbreaking experiment. Utilizing a 12-inch glass lens, he concentrated sunlight on mercuric oxide in an inverted glass container within a pool of mercury. The resulting colorless, odorless gas, which Priestley termed "dephlogisticated air," exhibited remarkable properties. It intensely fueled a flame and prolonged a mouse's survival compared to a similar air volume. Priestley theorized that the gas supported combustion exceptionally well because it lacked phlogiston, absorbing the maximum amount during burning.

Despite its effects being indistinguishable from standard air, Priestley noted a peculiar lightness in his chest. Speculating on its potential popularity as a luxury item, he mused that only two mice had experienced breathing this pure air beside himself. Following this discovery, Priestley visited France and crossed paths with Antoine Lavoisier, a fellow gas investigator. "Dephlogisticated air" became a crucial clue for Lavoisier, leading to his groundbreaking theory of chemical reactions that refuted the phlogiston hypothesis. According to Lavoisier, burning substances didn't emit phlogiston but absorbed Priestley's gas. He named the gas "oxygen" from the Greek term for acid-maker due to its role in producing acids when combined with non-metals.

This encounter marked a pivotal moment in the "revolution" of chemistry, challenging established notions and paving the way for a more accurate understanding of chemical processes. Lavoisier's work discredited the phlogiston theory, establishing oxygen as a key player in chemical reactions—a milestone that reshaped the chemistry landscape [3].

3. Interesting facts

Liquid and solid oxygen are pale blue

While oxygen gas is colorless and odorless, it is pale blue in its liquid or solid state. This is due to light absorption in the red part of the visible spectrum, which results in a blue hue. Liquid oxygen is used in some rocket propulsion systems and is highly reactive.

Two atoms of oxygen make up an oxygen molecule, but there’s also ozone

Most of the oxygen in the atmosphere is in the form of diatomic molecules (O_2). However, there’s another form known as ozone (O_3), which consists of three oxygen atoms. Ozone plays a crucial role in the Earth’s stratosphere by absorbing most of the Sun’s harmful ultraviolet radiation, protecting Earth's life from its detrimental effects.

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Oxygen makes up about 21% of Earth's atmosphere

Earth's atmosphere is composed primarily of nitrogen (about 78%) and oxygen (about 21%), with small amounts of argon, carbon dioxide, and other trace gases. This 21% of oxygen is vital for the survival of aerobic organisms. When Earth first formed, it had little to no free oxygen. Over billions of years, photosynthetic organisms' evolution increased atmospheric oxygen concentration, paving the way for the development of oxygen-breathing life [4].

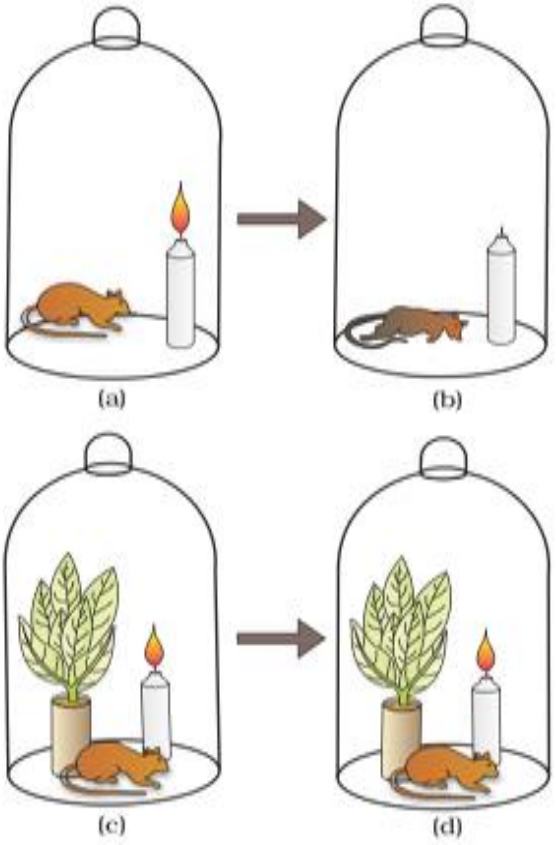

Figure 2. Priestley's experiment (a) a mouse is placed with a burning candle in a sealed glass container to create a closed environment (b) as the candle burned, it consumed all oxygen, making the mouse not able to breathe (c) the mouse is placed with a burning candle and sprig of mint (d)the mint released oxygen allowing mouse breath and the candle to burn again [5].

Oxygen is the third most abundant element in the universe by mass

After hydrogen and helium, oxygen is the most abundant element found in the universe. It plays a pivotal role in the life cycle of stars and is a primary component of water (H_2O), making it essential for the possibility of life as we understand it on other planets.

Humans can't breathe 100% pure oxygen for extended periods

While oxygen is essential for survival, breathing 100% pure oxygen for extended periods can be harmful. It can lead to oxygen toxicity, which affects the central nervous

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system and the lungs. In environments like hospitals, patients are sometimes given high oxygen concentrations, but it's carefully monitored to avoid harmful effects.

Without oxygen, the Earth's oceans would evaporate

Oxygen plays a vital role in the Earth's water cycle. Water is made up of hydrogen and oxygen. Without oxygen, water wouldn't exist, and the oceans would evaporate. The presence of liquid water on Earth is one of the primary reasons our planet can support life [5].

4. Conclusions

The discovery of oxygen marked a pivotal moment in scientific history, revolutionizing our understanding of combustion and respiration. This crucial finding by scientists like Joseph Priestley and Antoine Lavoisier laid the foundation for modern chemistry, emphasizing the role of oxygen in sustaining life and supporting combustion reactions. Today, the significance of this discovery resonates across various scientific disciplines, contributing to advancements in medicine, industry, and environmental science.

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