Fluorine: Properties, Structure and Uses

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Abstract: Fluorine is a highly reactive non-metal and the lightest member of the halogen group. It is the most electronegative element in the periodic table, which explains its strong ability to form compounds with almost all other elements. Fluorine is a pale yellow gas at room temperature and does not occur freely in nature. It is found only in stable compounds due to its extreme reactivity. Despite dangerous properties, fluorine and its compounds are widely used in everyday life, including toothpaste, medicine, and medical imaging. Its unique physical and chemical characteristics make fluorine an important element in both science and modern technology.

Keywords: halogens; electronegativity; chemical reactivity; electron configuration; fluorides; periodic table; physical properties

1. Introduction

Fluorine is one of the most striking elements in the periodic table and is known for its extreme reactivity, distinctive physical behavior, and essential role in modern chemistry. As the lightest element in the halogen family (a non-metal), fluorine is unique, with its ability to bond, react, and change the properties of other substances. Its discovery, properties, and uses make it an important element in both scientific theory and real-world technology.

Fluorine has the atomic number 9, which means most common isotope of fluorine contain 9 p^+ (protons), 10 n^0 (neutrons), and 9 e^- (electrons). These numbers are what define fluorine as a unique element. The most common atomic mass of fluorine is approximately 19 atomic mass units, or more precisely, 18.998 (Figure 1). Because fluorine's mass is so close to 19, that number is often used when scientists are working with the element's properties in chemistry.

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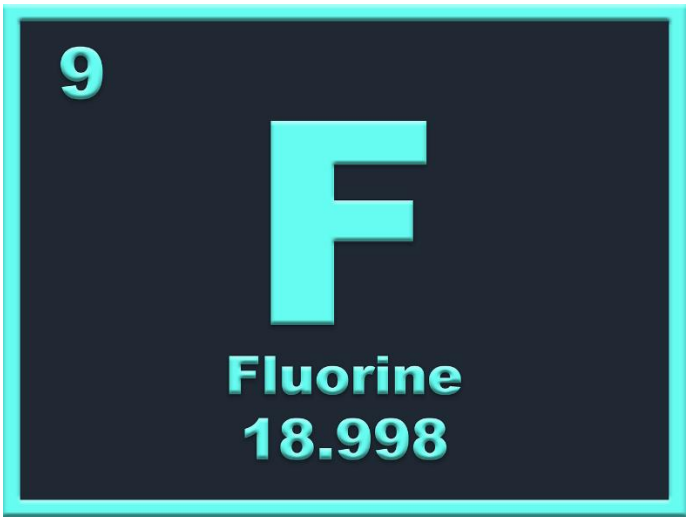

Figure 1. Symbol of fluorine with atomic and mass information.[1]

Fluorine is placed in Group 17, also known as the halogen group. Other elements in this group are chlorine, bromine, iodine, and astatine. Elements in this group all have 7 electrons in their outer shell (Figure 2). This makes them highly reactive, especially with metals, because they only need one more electron to complete a stable octet (eight-electron arrangement).

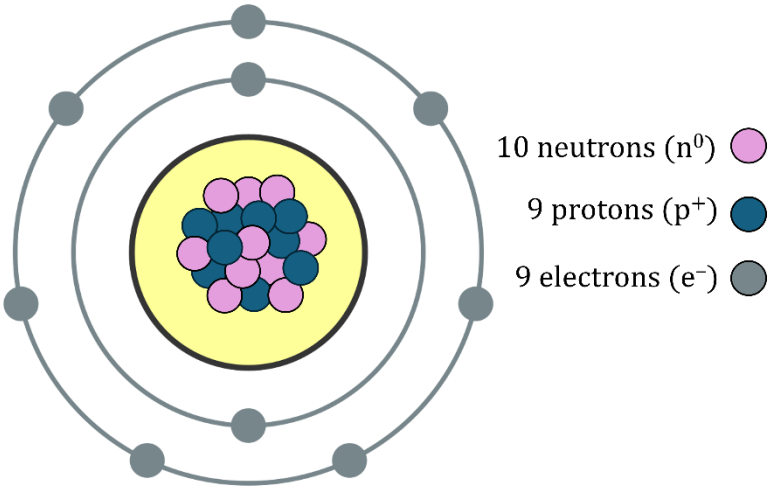

Figure 2. Bohr model of the fluorine atom.

[1] Figure is original work of DerrickSherrill, available at Pixabay. Please consider supporting this author by visiting the following link https://pixabay.com/illustrations/fluorine-element-periodic-table-4300493/

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Within this group, fluorine is at the top, making it the most electronegative and the most electronegative and the most reactive element among the halogens, and in the entire periodic table.

2. Physical properties of fluorine

Fluorine is a pale yellow gas at room temperature, similar to chlorine, but lighter and more reactive. Its boiling point is approximately −188 °C, and its melting point is approximately −220 °C.

Fluorine has a sharp, irritating smell and it is very dangerous due to its high reactivity, but beware – it can attack almost every material.

Fluorine has one stable natural isotope, ^{19}F. The radioactive isotope ^{18}F is widely used in medical imaging, especially in PET scans.

Fluoride compounds are used daily in toothpaste, medicine, and medical imaging. Although elemental fluorine is dangerous, its compounds are safely used for health-related purposes. Some fluorine isotopes are radioactive, which is why their use is strictly controlled in medicine. Fluoride compounds in toothpaste are safe in small amounts and help protect teeth. However, toothpaste should not be swallowed.

For the electron configuration, you can say $1s^2\ 2s^2\ 2p^5$. Therefore, the shell distribution can be written as 2, 7.

3. Chemical properties of fluorine

The chemical behavior of fluorine is mainly determined by its very high electronegativity, which is the highest among all elements. Because of this property, fluorine readily attracts electrons and forms compounds with almost every other element, including noble gases such as xenon.

Fluorine is a very strong oxidizing agent because it easily removes electrons from other substances during chemical reactions. As a result, elemental fluorine does not occur freely in nature and is found only in the form of stable compounds, known as fluorides. These compounds play an important role in many chemical and industrial processes.

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4. Fluorine in everyday life

Although elemental fluorine is highly dangerous, its compounds are extremely useful in everyday life. Fluoride compounds are commonly found in toothpaste, where they help strengthen tooth enamel and prevent tooth decay. In medicine, radioactive ^{18}F is used in PET scans to help doctors diagnose various diseases.

Fluorine-based materials, such as polytetrafluoroethylene (teflon), are widely used in industry due to of their exceptional to heat and chemical damage. These examples show how a very reactive element can become highly beneficial when used in controlled and safe forms.

Table 1. Benefits and potential risks of fluorine compounds

Benefits	**Potential risks**
Tooth decay prevention	Toxic in high doses
Medical imaging (PET scans)	High reactivity of elemental fluorine
Industrial applications	Requires careful handling

5. Conclusions

Fluorine is an element that clearly shows how atomic structure influences chemical behavior. Its small atomic size and high electronegativity make it extremely reactive, which explains why it is rarely found in elemental form in nature. Although elemental fluorine is dangerous, its compounds play an essential role in everyday life, especially in dentistry, medicine, and modern technology. Studying fluorine helps students better understand periodic trends, chemical bonding, and the connection between chemistry and real-world applications.

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