

15.8: The Importance of Ions to a Chemist

Learning Objectives

- Identify how a charge affects the electron count of an element.
- Apply a provided charge when calculating the number of subatomic particles.
- Realize that cations are atoms that lose electrons resulting in an overall positive charge.
- Realize that anions are atoms that gain electrons resulting in an overall negative charge.
- Locate regions of the periodic table where cations and anions tend to form.
- Know that chemical energy corresponds to electrons, while nuclear energy results from changing the nucleus.
- Compare and contrast chemical and nuclear energy.

Chemists appreciate isotopes and use them in basic and applied research. However, they are more concerned with the movement of electrons. When an atom gains or loses electrons, it becomes a charged species or an ion. When this occurs, the nucleus is not altered. For atoms that lose electrons, an overall positive charge will result (**#protons > #electrons**). Atoms that form these types of ions are called cations. Metal atoms (located on the left side of the periodic table) always lose electrons to become cations.

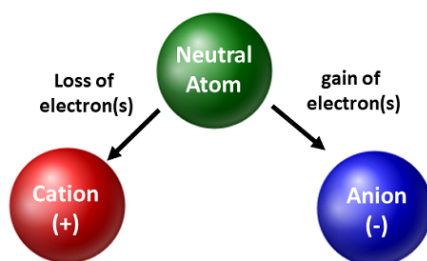


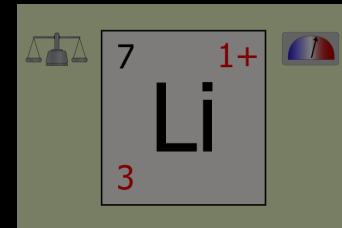
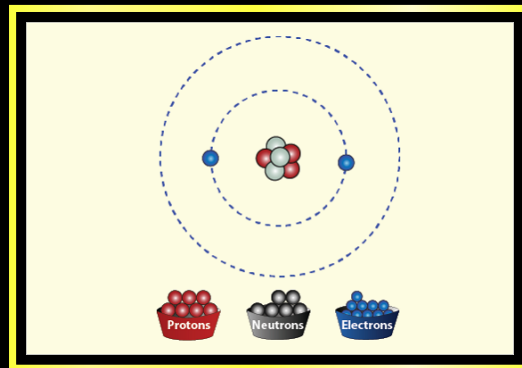
Figure 15.8.1: Neutral atoms become ions by either losing an electron (to form positively charged cations) or gaining electrons (to form negatively charged anions). (Public Domain; Delmar Larsen)

Unlike metal atoms, nonmetals will gain electrons to become anions. These types of ions have an overall negative charge (**#electrons > #protons**). With the exception of the noble gases, all atoms on the periodic table will lose or gain electrons to achieve electronic stability. Different types of bonding occur when atoms lose, gain, or share electrons. These types of atomic connections will be further discussed in chapter 4 of your textbook.

Interactive: Building an Atom

Build an atom out of protons, neutrons, and electrons, and see how the element, charge, and mass change. Then play a game to test your ideas!

Build an Atom



Symbol

Atom

At this point, you should be able to calculate all subatomic particles when given a specific ion charge. In addition, you should master classifications of ions (recognizing cations are positive and anions are negative). Memorizing charges of specific ions will be required when working on chapter 4 in the textbook. **For now, ion charges will be provided and should not be memorized.** Note and appreciate the ion charges for main group elements in the periodic table below. Lastly, chemists do not write a number for charges involving the number one (1). For these species, you will only see a + or - sign. Charges of higher magnitude will always have a number associated with the elemental symbol.

1A						8A
H ⁺	2A					
Li ⁺						
Na ⁺	Mg ²⁺					
K ⁺	Ca ²⁺					
Rb ⁺	Sr ²⁺					

	3A	4A	5A	6A	7A	
			N ³⁻	O ²⁻	F ⁻	
	Al ³⁺		P ³⁻	S ²⁻	Cl ⁻	
				Se ²⁻	Br ⁻	
					I ⁻	

Figure 15.8.2: Periodic Table with ion charges of common main group elements. The charge that an atom acquires when it becomes an ion is related to the structure of the periodic table. Within a group (family) of elements, atoms form ions of a certain charge. Please note that hydrogen can adopt a + or - charge. When the word hydride is used, this means that hydrogen has a - charge.

✓ Example 15.8.1: Ionic Classification

Calculate the subatomic particles for the species below using the information in Figure 15.8.2. Label each as being an atom, cation, or anion. Refer to the periodic table for masses, atomic numbers, and specific ion charges.

- Aluminum ion
- Zirconium atom
- Sulfur ion

Solutions

- There are 13 protons, 14 neutrons, and 10 electrons in the aluminum ion. This ion is positively charged which means it has lost electrons and forms a cation.
- There are 40 protons, 51 neutrons, and 40 electrons in the zirconium atom. This is an atom which has no overall charge.
- There are 16 protons, 16 neutrons, and 18 electrons in the sulfur ion. This ion is negatively charged which means it has gained electrons and forms an anion.

✓ Example 15.8.2: A/Z and symbol mass notations

Write A/Z and symbol mass notations for the ions/atom in the previous question.

Solutions

- ${}_{13}^{27}\text{Al}^{3+}$ and Al-27
- ${}_{40}^{91}\text{Zr}$ and Zr-91
- ${}_{16}^{32}\text{S}^{2-}$ and S-32

If an atom gains or loses electrons, this should be represented on the A/Z format. The symbol-mass format does not display ion charge. Remember, neutrons and protons are not affected by changes of electrons.

Need More Practice?

- Turn to Section 3.E of this OER and work problems #5 and #9.

Contributors

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