

# Teacher Guide: Ionic Bonds



## Learning Objectives

Students will ...

- Understand that atoms are most stable with a full set of eight valence electrons.
- Calculate the charge of an ion by subtracting the number of electrons from protons.
- Model ionic bonds between a wide variety of metals and nonmetals.
- Discover that atoms of elements in the same chemical family have the same number of valence electrons. (Extension)



## Vocabulary

chemical family, electron affinity, ion, ionic bond, metal, nonmetal, octet rule, shell, valence electron



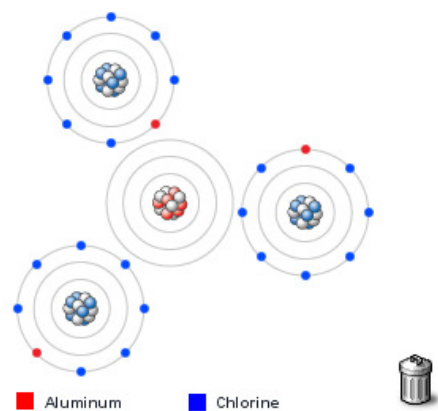
## Lesson Overview

Ionic bonds are formed when metal atoms give their valence electrons to nonmetal atoms. The resulting positively-charged metal ions are attracted to the negatively-charged nonmetal ions, forming a strong chemical bond.

The *Ionic Bonds Gizmo*<sup>™</sup> allows students to manipulate valence electrons, form ionic bonds, and create a variety of chemical compounds.

The Student Exploration sheet contains two activities and an extension:

- Activity A – Students explore what happens when atoms gain or lose electrons.
- Activity B – Students use ionic bonds to create chemical compounds.
- Extension – Students find that elements in the same chemical family have similar electron configurations.



## Suggested Lesson Sequence

1. **Pre-Gizmo activity: Sticky balloon** (🕒 5 – 15 minutes)

The force that holds atoms together in an ionic bond is the *electrostatic force*. To demonstrate this force, rub a balloon on your head for a few seconds, then place the balloon on your head and let go. The balloon will stay there. You can slowly lift the balloon from your head to show your hair sticking to the balloon. After the balloon is removed, your hair will continue to stick up away from your head.

Ask your students what they think is going on. Explain that electrons are transferred from your hair to the balloon. The balloon becomes negatively charged, while your hair is now positively charged. This results in an attractive force between your hair and the balloon. When the balloon is removed, the positively charged hairs will repulse one another.

2. **Prior to using the Gizmo** (🕒 10 – 15 minutes)

Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (🕒 15 – 20 minutes per activity)

Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (🕒 15 – 30 minutes)

As students are working or just after they are done, discuss the following questions:

- How do ions form? Why do they form?
- How does the formation of ions lead to the creation of an ionic bond?
- Knowing the charges of ions, how can you predict the chemical formula of a compound? [Ions combine so that the net charge is zero. For example, two  $\text{Na}^{1+}$  ions are needed to balance the charge of one  $\text{O}^{2-}$  ion.]
- What do atoms of elements in the same chemical family have in common?
- Look at your periodic table. What chemical formula would you predict for a compound of strontium and arsenic? [ $\text{Sr}_3\text{As}_2$ , also called strontium arsenide]

5. **Follow-up activities** (🕒 45 – 60 minutes)

There are several fun ways to follow up the *Ionic Bonds* Gizmo. The [Teacher Guide](#) for the *Element Builder* Gizmo (see the **Selected Web Resources** on the next page of this document) describes a way to build atom models using construction paper, markers, staples, tape, and colored beads. The same models can be used to model ionic bonds.

First, have students work in pairs. One partner can build an atom of sodium, while the other can build fluorine. The sodium atom transfers its valence electron to the fluorine atom. The positively charged sodium ion then forms a bond with the negatively charged fluorine atom. Using similar methods, students can model any of the ionic bonds presented in the *Ionic Bonds* Gizmo.

To demonstrate electrostatic attraction and repulsion, give each student two pieces of transparent tape. Fold over the end of each piece to make a “handle,” and then place one piece to the other so that the sticky side of the top piece is firmly stuck to the non-sticky side of the bottom piece. With a rapid motion, grasp the two handles and pull the pieces apart. Label the top piece with a “–” sign and the bottom piece with a “+” sign.

Holding the tape pieces by the handle, carefully bring two “–” or two “+” pieces close together. The pieces will repel one another. Then bring a “+” piece near a “–” piece to observe attraction.

Finally, a natural follow-up to ionic bonds is to study covalent bonds. The *Covalent Bonds* Gizmo uses a similar simulation to demonstrate how the sharing of electrons leads to the formation of a covalent bond.



## Scientific Background

There are four fundamental forces in the universe: the strong nuclear force, the weak nuclear force, the electromagnetic force, and gravity. The electromagnetic force describes the forces that arise between charged objects. There is an attractive force between objects with opposite charges and a repulsive force between objects with the same charge.

Electrostatic charge is carried by protons and electrons. Protons have a charge of  $1+$ , while electrons have a charge of  $1-$ . A neutral atom has an equal number of protons and electrons. When an atom gains or loses electrons, it becomes a positively or negatively charged *ion*. Only the outermost electrons, or *valence electrons*, are exchanged by atoms.

Metals are atoms with relatively few valence electrons. They have a low *electron affinity*, which means that they hold onto their valence electrons very loosely. Nonmetals generally have five, six, or seven valence electrons. They have a high electron affinity and tend to gain electrons. When metals and nonmetals interact, the metal atoms tend to lose their valence electrons and the nonmetals tend to gain valence electrons until they have a stable set of eight valence electrons. The exchange of electrons results in the formation of ions and ionic bonds.

The chemical formula of the resulting compound can be predicted from the numbers of valence electrons. For example, beryllium atoms have two valence electrons, and fluorine atoms have seven. A single beryllium atom can donate an electron to two fluorine atoms, resulting in the compound beryllium fluoride, or  $\text{BeF}_2$ . Aluminum atoms have three valence electrons, while oxygen atoms have six. Two aluminum atoms can donate six valence electrons to three oxygen atoms, resulting in the stable compound aluminum oxide, or  $\text{Al}_2\text{O}_3$ .



## Health Connection: Essential ions

Ions are essential to all living things and are utilized in a variety of ways. A healthy diet is necessary to obtain adequate amounts of these nutrients:

- Calcium ( $\text{Ca}^{2+}$ ) is used as a neurotransmitter, enzyme cofactor, in muscle contractions, and to form bones.
- Magnesium ( $\text{Mg}^{2+}$ ) is essential for the proper function of ATP, the main source of energy in our bodies. Magnesium also plays a role in the formation of DNA and RNA.
- Potassium ( $\text{K}^+$ ) and sodium ( $\text{Na}^+$ ) ions are found inside and outside of cells. Like calcium ions, they help to generate electrical potential differences that are utilized in neurotransmitters and muscle contractions.
- Phosphorus ( $\text{P}^{3-}$ ) is an essential component of DNA, RNA, ATP, cell membranes, and bones.



## Selected Web Resources

Types of chemical bonds: <http://hyperphysics.phy-astr.gsu.edu/hbase/chemical/bond.html>

Chemical bonding: [http://www.visionlearning.com/library/module\\_viewer.php?mid=55](http://www.visionlearning.com/library/module_viewer.php?mid=55)

Ionic bonding tutorial: [http://www.teachersdomain.org/asset/lsps07\\_int\\_ionicbonding/](http://www.teachersdomain.org/asset/lsps07_int_ionicbonding/)

Sticky tape and other experiments: <http://www.eskimo.com/~billb/emotor/sticky.html>

Related Gizmos:

*Element Builder*: <http://www.explorellearning.com/gizmo/id?424>

*Covalent Bonds*: <http://www.explorellearning.com/gizmo/id?512>