

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Student Exploration: Ionic Bonds

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

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

1. Nate and Clara are drawing pictures with markers. There are 8 markers in a set. Nate has 9 markers and Clara has 7. What can Nate and Clara do so that each of them has a full set?

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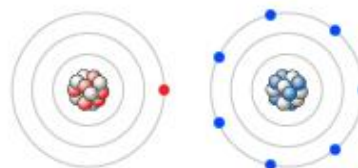
2. Maggie is sitting at a table with Fred and Florence. Maggie has 10 markers, but Fred and Florence each have only 7 markers. How can they share markers so each has 8?

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### Gizmo Warm-up

Just like students sharing markers, atoms sometimes share or swap electrons. By doing this, atoms form bonds. The *Ionic Bonds* Gizmo™ allows you to explore how **ionic bonds** form.

To begin, check that **Sodium (Na)** and **Chlorine (Cl)** are selected from the menus at right. Click **Play** (▶) to see electrons orbiting the nucleus of each atom. (Note: These atom models are simplified and not meant to be realistic.)



1. Each atom consists of a central nucleus and several **shells** that contain electrons. The outermost electrons are called **valence electrons**. (Inner electrons are not shown.)

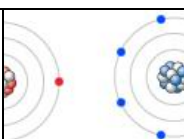
How many valence electrons does each atom have? Sodium: \_\_\_\_\_ Chlorine: \_\_\_\_\_

2. Click **Pause** (⏸). Elements can be classified as **metals** and **nonmetals**. Metals do not hold on to their valence electrons very tightly, while nonmetals hold their electrons tightly. **Electron affinity** is a measure of how tightly the valence electrons are held.

A. Try pulling an electron away from each atom. Based on this experiment, which atom is a metal? \_\_\_\_\_ Which is a nonmetal? \_\_\_\_\_

B. Try moving an electron from the metal to the nonmetal. What happens? \_\_\_\_\_

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<b>Activity A:</b> <b>Ions</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>.</li> <li>• Check that sodium and chlorine are still selected.</li> </ul>	
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**Introduction:** Some of the particles that make up atoms have an electrical charge. Electrons are negatively charged, while protons are positively charged. Particles with opposite charges (+ and –) attract, while particles with the same charge (+ and + or – and –) repel.

**Question: What happens when atoms gain or lose electrons?**

1. Count: Electrons move around the nucleus of atoms in specific shells, shown by the rings around the atoms in the Gizmo. The first ring holds two electrons, and the second holds eight. (Electrons in the inner rings are not shown; you can assume these rings are full.)

A. Observe the sodium and chlorine atoms. Assuming that the inner rings are full of electrons, how many electrons are there total in each atom?

Sodium: \_\_\_\_\_ Chlorine: \_\_\_\_\_

B. Each atom is neutrally charged, which means that each atom has the same number of protons and electrons. Based on this, how many protons are in each atom?

Sodium: \_\_\_\_\_ Chlorine: \_\_\_\_\_

2. Observe: Most atoms are stable with a configuration of eight valence electrons. This is known as the **octet rule**. How many *valence* electrons does each atom have?

Sodium: \_\_\_\_\_ Chlorine: \_\_\_\_\_

3. Form a bond: Each electron has a charge of  $1-$ , and each proton has a charge of  $1+$ . You can calculate the charge of an atom by subtracting the number of electrons from the number of protons. Move an electron from the sodium to the chlorine atom.

A. What are the charges of each atom now? Sodium: \_\_\_\_\_ Chlorine: \_\_\_\_\_

Turn on **Show charge** to check. These charged atoms are called **ions**.

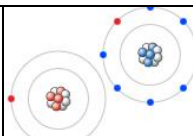
B. Is each ion stable? Explain. \_\_\_\_\_

\_\_\_\_\_

Click **Check** in the lower right corner of the Gizmo to check.

4. Think and discuss: Why is there an attraction between the two ions in this chemical bond?

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<b>Activity B:</b> <b>Ionic compounds</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Click <b>Reset</b>. Turn off <b>Show charge</b>.</li> <li>Select <b>Lithium (Li)</b> and <b>Oxygen (O)</b>.</li> </ul>	
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**Question: How are ionic compounds formed?**

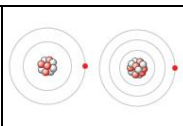
- Observe:** Look at the red lithium atom and the blue oxygen atom. Recall that most atoms are stable when their outermost ring has eight electrons. (Some atoms, such as lithium and beryllium, are stable when their outermost ring has two electrons.)

  - How many electrons will the lithium atom give up to become stable? \_\_\_\_\_
  - How many electrons does the oxygen atom need to become stable? \_\_\_\_\_
  - Can a stable compound be made from these two atoms? Explain why or why not.  
 \_\_\_\_\_  
 \_\_\_\_\_
- Form bonds:** Click **Add metal** to add another lithium atom, and then transfer electrons from the lithium to the oxygen. Click **Check**.

  - Did you make a stable compound? \_\_\_\_\_
  - Turn on **Show formula**. What is the formula of this compound? \_\_\_\_\_
  - Turn on **Show charge**. What is the charge of each ion? Li \_\_\_\_\_ Li \_\_\_\_\_ O \_\_\_\_\_
- Practice:** Use the Gizmo to create stable compounds from the combinations given below. After transferring electrons, arrange the atoms to demonstrate the attraction between positively charged ions and negatively charged ions. Click **Check** to check each compound.

For each compound, click the **camera** (📷) to take a snapshot. Paste each image into a blank document to turn in with this worksheet. Write the ionic charges (such as  $\text{Ca}^{2+}$ ) and chemical formulas below.

	<b>Ionic charges</b>	<b>Chemical formula</b>
A. Lithium and fluorine:	Li ___ F ___	_____
B. Beryllium and oxygen:	Be ___ O ___	_____
C. Magnesium and fluorine:	Mg ___ F ___	_____
D. Aluminum and chlorine:	Al ___ Cl ___	_____
E. Beryllium and nitrogen:	Be ___ N ___	_____

<b>Extension:</b> <b>Chemical families</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Select <b>Lithium (Li)</b> from the <b>Select a metal</b> list.</li> <li>• You will need a periodic table for this activity.</li> </ul>	
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**Introduction:** The periodic table arranges elements by size and property. The vertical columns represent **chemical families**, or groups of elements with similar chemical properties.

**Question: How are elements arranged into chemical families?**

- Observe: Drag the nonmetal into the trash (🗑️) so there is only the one lithium atom visible.
  - How many valence electrons does lithium have? \_\_\_\_\_
  - Now look at your periodic table. Find lithium (Li) in the first column. Other than lithium, which element from the Gizmo is also in this column? \_\_\_\_\_
  - Choose this element. How many valence electrons does this element have? \_\_\_\_\_
- Gather data: Four other pairs of elements in the same chemical family are listed below. List the number of valence electrons in each element.

Beryllium _____ Magnesium _____	Nitrogen _____ Phosphorus _____	Oxygen _____ Sulfur _____	Fluorine _____ Chlorine _____
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- Analyze: What pattern do you see? \_\_\_\_\_  
\_\_\_\_\_
- Make a rule: Based on your data, how are elements arranged into chemical families?  
\_\_\_\_\_  
\_\_\_\_\_
- Infer: Look at your periodic table. How many valence electrons would you find for elements in each family?    Boron family: \_\_\_\_\_    Carbon family: \_\_\_\_\_    Neon family: \_\_\_\_\_
- Think and discuss: How do you think the number of valence electrons relates to an element's chemical properties? \_\_\_\_\_  
\_\_\_\_\_