



Student Exploration: Covalent Bonds

Vocabulary: covalent bond, diatomic molecule, Lewis diagram, molecule, noble gases, nonmetal, octet rule, shell, valence, valence electron

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

1. There are eight markers in a full set, but Flora and Frank each only have seven markers. Flora is missing the red marker, and Frank is missing the blue marker.

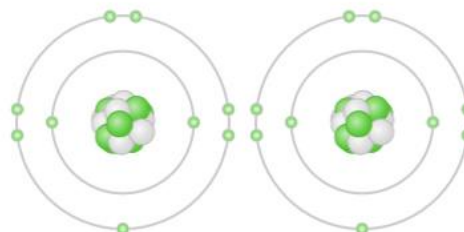
What can they do so that each has a full set of markers? _____

2. Otto and Olivia each have six markers. Otto is missing the purple and green markers, and Olivia is missing the black and brown markers. What can they do so that each has a full set?

Gizmo Warm-up

Just like the students described above, **nonmetal** atoms can share valence electrons. As you will see in the *Covalent Bonds* Gizmo, atoms form covalent bonds in this way.

To begin, check that **Fluorine** is selected from the **Select a molecule** menu. Click **Play** (▶) to see the electrons orbiting the nucleus of two fluorine atoms.



1. The outermost electrons in each atom are called **valence electrons**. How many valence electrons does each fluorine atom have? _____

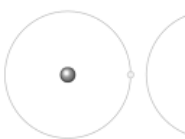
2. Click **Pause** (⏸). Drag a valence electron from the left atom to the right atom. Click **Play**.

What happens? _____

3. Click **Pause**, drag a valence electron from the right atom to the left, and then click **Play**.

What happens now? _____



Activity A: Sharing electrons	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Click Reset. • Select Hydrogen. 	
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Introduction: The electrons that orbit the nucleus of an atom are arranged into **shells**. The first shell contains up to two electrons and the second contains up to eight electrons. Most elements are stable when they have eight valence electrons—a rule of thumb known as the **octet rule**. (Elements with less than five electrons are stable with *two* valence electrons.)

Question: What happens when atoms share electrons?

1. Predict: Each hydrogen atom has one valence electron, but it needs two electrons to be stable. How can both hydrogen atoms each achieve a stable configuration?

2. Form a bond: Drag the electrons so that they move around both hydrogen atoms. Click **Play** to observe them in orbit, and then click **Check**. You have created a **covalent bond**.

Congratulations, you have completed a **molecule** of hydrogen! Because the molecule has two atoms, it is a **diatomic molecule**. Sketch a snapshot of your completed molecule and label the image appropriately.

3. Draw a diagram: Covalent bonds are shown in **Lewis diagrams**. In a Lewis diagram, dots represent unshared valence electrons and dashes represent pairs of shared electrons.

Turn on **Show Lewis diagram**. What is the Lewis diagram for hydrogen, H₂? **H H**

4. Form a bond: Select **Fluorine** and turn on **Highlight shared electrons**. Create a molecule of fluorine, F₂. Take a snapshot of this molecule and add it to your document. (Be sure to label each molecule you add.)

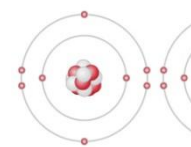
What is the Lewis diagram for fluorine, F₂? **F F**

5. Think and discuss: How is the formation of covalent bonds similar to kids sharing markers? How is it different? If possible, discuss your answer with your classmates and teacher.



Activity B:**Building molecules**Get the Gizmo ready:

- Click **Reset**.
- Turn off **Show Lewis diagram**.
- Select **Oxygen**.

**Question: How do atoms share more than one pair of electrons?**

1. Observe: Like fluorine and most other elements, oxygen atoms are most stable with a full complement of eight valence electrons.

A. How many valence electrons does each oxygen atom have now? _____

B. How many more electrons does each oxygen atom need to be stable? _____

2. Form a bond: Drag electrons back and forth until the molecule of oxygen (O_2) is stable. Click **Check** to confirm your molecule is stable. Take a snapshot and paste the image into your document (don't forget to label it " O_2 ").

Turn on **Highlight shared electrons**. How many *pairs* of shared electrons are there in a stable molecule of oxygen? _____

3. Draw a diagram: Draw a Lewis diagram of the oxygen molecule in the space below at left. To check your work, turn on **Show Lewis diagram**. Draw the correct diagram on the right.

Practice diagram: **O** **O**

Actual: **O** **O**

4. Practice: Create covalent bonds and stable molecules for the remaining substances. Take a snapshot of each completed molecule and add it to your document. Draw Lewis diagrams for each one. (As above, draw the diagram on your own before checking your work.)

Nitrogen

N **N**

H

Ammonia

H **N** **H**

Chlorine

Cl **Cl**

H

Water

H **O** **H**

Methane

H **C** **H**

H

Carbon dioxide

O **C** **O**

O

Formaldehyde

H **C** **H**

(Activity B continued on next page)



Activity B (continued from previous page)

5. Count: Review the Lewis diagrams you drew on the previous page. Note that each element tends to form a certain number of chemical bonds. This value is the **valence** of the element.

For each element in the table below, use the Gizmo to find the number of valence electrons and the list the valence based on the Lewis diagram. Then find the sum of these numbers.

Element	Symbol	# of valence electrons	Valence	Sum
Fluorine	F			
Hydrogen	H			
Oxygen	O			
Nitrogen	N			
Chlorine	Cl			
Carbon	C			

6. Make a rule: If you knew the number of valence electrons in a nonmetal atom, how would you determine the valence of the element? (Hint: Ignore hydrogen for now.)

7. Analyze: The first shell can hold a maximum of two electrons. How does this explain the valence of hydrogen?

8. Apply: Selenium has six valence electrons. What is the valence of selenium? _____

9. Think and discuss: The last column of the periodic table contains the **noble gases**, elements that do not easily form chemical bonds.

Why don't these gases tend to form chemical bonds? _____

