KEY IDEAS

As you read this section, keep these questions in mind:

• What are the three main categories of elements?
• Why do the elements in the same group have similar chemical properties?
• What happens to an atom that loses or gains an electron?

What Do Elements in a Group Have in Common?

All of the elements in a group on the periodic table have similar properties. Recall that an atom’s electrons move in orbitals at various energy levels. The electrons in the outermost energy level are called valence electrons. The number of valence electrons in an atom determines many of the chemical properties of an element.

In general, the atoms of elements in the same group have the same number of valence electrons. For example, lithium (Li) and sodium (Na) are both members of Group 1. All atoms of these elements have one valence electron. Because of this, lithium and sodium have similar chemical properties.

Valence electron

Lithium

\[ ^3 \text{Li} \]

Sodium

\[ ^1 \text{Na} \]

Lithium and sodium atoms have different numbers of electrons. However, they have the same number of valence electrons.

The repeating patterns of chemical properties shown in the periodic table are called periodic trends. Periodic trends are a result of the arrangement of electrons in atoms of each element.
PREDICTING ELECTRON ARRANGEMENTS

If you know where an element is located on the periodic table, you can predict its arrangement of electrons. As you move to the right across a period, the number of valence electrons increases. As you move down a group, the number of energy levels increases.

For example, boron and carbon are in the same period. Carbon has one more valence electron than boron has. Thus, carbon is located to the right of boron on the periodic table. Hydrogen and lithium are in the same group. Lithium has electrons in one more energy level than hydrogen does. Thus, lithium is located below hydrogen on the periodic table.

**LOOKING CLOSER**

3. **Identify** Which element has more valence electrons—neon or oxygen? Explain your answer.

<table>
<thead>
<tr>
<th>Element and symbol</th>
<th>Period</th>
<th>Group</th>
<th>Number of valence electrons</th>
<th>Number of energy levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen, N</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Barium, Ba</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
What Are Ions?

Some atoms do not have filled outermost energy levels. These atoms may undergo a process called ionization. During ionization, an atom may gain or lose valence electrons so that its outermost energy level is full.

If an atom gains or loses electrons, it will no longer have an equal number of electrons and protons. When the numbers of electrons and protons are not equal, the charges do not cancel one another out. This gives the atom an electric charge. A charged atom is called an ion. Many atoms can form ions. However, atoms of elements in Groups 1 and 17 form ions most easily.

Lithium is a group 1 element. When a lithium atom loses an electron, it becomes positively charged. Fluorine is a group 17 element. When a fluorine atom gains an electron, it becomes negatively charged.

GROUP 1

Atoms of elements in Group 1 are very reactive. That is, they react easily with atoms of other elements. Group 1 elements are very reactive because each of their atoms has one valence electron. A single valence electron can be removed easily from an atom. When an atom loses an electron, it becomes a positive ion. Positive ions are called cations. A positive ion has a superscript “+” next to the element symbol. For example, a lithium ion with a charge of +1 is written Li⁺.
GROUP 17

Atoms of elements in Group 17 are also very reactive. Group 17 elements are very reactive because each of their atoms has seven valence electrons. Each of these atoms needs only one more electron to fill its outermost energy level. Atoms of Group 17 elements easily gain electrons. When an atom gains an electron, it becomes a negative ion. Negative ions are called anions. An anion has a superscript “−” next to the element symbol: F−.

OTHER GROUPS

Atoms of elements in Groups 2 through 16 can also form ions. These atoms have to lose or gain more than one electron in order to have a filled outermost energy level. In general, atoms with fewer than four valence electrons lose electrons to form cations. Atoms with more than four valence electrons gain electrons to form anions.

Ions of elements in Groups 2 through 16 are also indicated with superscripts. However, the symbols for these ions also show how many electrons were gained or lost. For example, magnesium loses its two valence electrons to form a cation: Mg2⁺.

What Are the Three Categories of Elements?

Recall that elements in the same group share similar chemical properties. The elements in the 18 groups of the periodic table are also classified into three larger categories. These categories are based on general properties that the elements share.

LOOKING CLOSER

9. Identify Which category contains the most elements?

10. Identify Which category contains the fewest elements?

8. Infer Which atom would be more reactive—F or F⁻? Explain your answer.
### Three Categories of Elements

<table>
<thead>
<tr>
<th>Category</th>
<th>Properties</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Metals       | • good conductors of electricity  
                • good conductors of thermal energy  
                • ductile (easily formed into wires) and malleable (easily shaped or formed)  
                • generally shiny solids | ![Lead](Lead.png) |
| Nonmetals    | • poor conductors of electricity  
                • poor conductors of thermal energy  
                • not ductile or malleable  
                • generally not shiny  
                • may be solids, liquids, or gases | ![Carbon](Carbon.png) |
| Semiconductors | • share properties with metals and nonmetals  
                            • can conduct electricity under certain conditions | ![Tellurium](Tellurium.png) |

**LOOKING CLOSER**

11. **Apply Concepts** Into which category would you place a shiny substance that is used to make flexible bed springs?

12. **Apply Concepts** Into which category would you place a brittle substance that does not conduct heat?

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A **metal** is an element that is a good conductor of electricity and heat. An element that is not a good conductor of electricity and heat is called a **nonmetal**. Some elements conduct electricity only under certain conditions. Such elements are called **semiconductors**. Semiconductors are also called **metalloids**.
Section 2 Review

SECTION VOCABULARY

| **ion** | an atom, radical, or molecule that has gained or lost one or more electrons and has a negative or positive charge |
| **nonmetal** | an element that conducts heat and electricity poorly and that does not form positive ions in an electrolytic solution |
| **metal** | an element that is shiny and that conducts heat and electricity well |
| **semiconductor** | an element or compound that conducts electric current better than an insulator does but not as well as a conductor does |

1. **Compare**  Compare the number of valence electrons in an atom of oxygen and an atom of selenium. Are these two elements in the same period or the same group?

2. **Explain**  How does a cation differ from an anion?

3. **Predict**  Atoms of cesium can lose electrons to become cations. How many electrons does a single cesium atom lose? Explain your answer.

4. **Explain**  Why do elements in groups share more chemical properties than elements in a period?

5. **Explain**  Why do some atoms gain electrons to form ions and some lose electrons?