Chapter 4
Compounds and Their Bonds

4.5 Polyatomic Ions
4.6 Covalent Compounds
4.7 Bond Polarity

Covalent Bonds
- Formed between two nonmetals in 4A, 5A, 6A, and 7A
- Nonmetals have high electronegativity values
- Electrons are shared
  - single bond shares one pair electrons
  - double bond shares two pairs electrons
  - triple bond shares three pairs electrons

Learning Check
Indicate whether a bond between the following would be 1) Ionic 2) covalent

- A. sodium and oxygen
- B. nitrogen and oxygen
- C. phosphorus and chlorine
- D. calcium and sulfur
- E. chlorine and bromine

Covalent Bonds
Two nonmetal atoms form a covalent bond because they have less energy after they bonded
H* + H → H : H = H–H = H₂

Diatomic Molecules
Gases that exist as diatomic molecules are H₂, F₂, N₂, O₂, Cl₂, Br₂, I₂

N* + N* → N::N

triple bond
Learning Check

Use the name of the element to name the following diatomic molecules.

<table>
<thead>
<tr>
<th>Element</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>hydrogen</td>
</tr>
<tr>
<td>N₂</td>
<td>nitrogen</td>
</tr>
<tr>
<td>Cl₂</td>
<td>chlorine</td>
</tr>
<tr>
<td>O₂</td>
<td>oxygen</td>
</tr>
<tr>
<td>I₂</td>
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Solution

Use the name of the element to name the following diatomic molecules.

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Covalent Bonds in NH₃

Bonding pairs

H

H : N : H

Lone pair of electrons

Naming Binary Covalent Compounds

Two nonmetals
- Name each element
- End the last element in -ide
- Add prefixes to show more than 1 atom

Prefixes

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>mon</td>
<td>1</td>
</tr>
<tr>
<td>di</td>
<td>2</td>
</tr>
<tr>
<td>tri</td>
<td>3</td>
</tr>
<tr>
<td>tetra</td>
<td>4</td>
</tr>
<tr>
<td>penta</td>
<td>5</td>
</tr>
<tr>
<td>hexa</td>
<td>6</td>
</tr>
</tbody>
</table>

Learning Check

Fill in the blanks to complete the following names of covalent compounds.

- CO carbon ___ oxide
- CO₂ carbon ___
- PCl₃ phosphorus ___ chloride
- CCl₄ carbon ___ chloride
- N₂O ___ nitrogen ___ oxide

Solution

- CO carbon monoxide
- CO₂ carbon dioxide
- PCl₃ phosphorus trichloride
- CCl₄ carbon tetrachloride
- N₂O dinitrogen monoxide
Learning Check

A. $P_2O_5$
   1) phosphorus oxide
   2) phosphorus pentoxide
   3) diphosphorus pentoxide

B. $Cl_2O_7$
   1) dichlorine heptoxide
   2) dichlorine oxide
   3) chlorine heptoxide

C. $Cl_2$
   1) chlorine
   2) dichlorine
   3) dichloride

Solution

A. $P_2O_5$
   3) diphosphorus pentoxide

B. $Cl_2O_7$
   1) dichlorine heptoxide

C. $Cl_2$
   1) chlorine

Electronegativity

- The attraction of an atom for electrons is called its electronegativity.
- Fluorine has the greatest electronegativity.
- The metals have low electronegativities.

Bond Polarity: Nonpolar

Nonpolar covalent bond
- Electrons are shared between atoms with the same electronegativity values.
- Difference = 0
- Examples:
  $N_2$  $Br_2$

Bond Polarity: Polar

Polar covalent bond
- Electrons are shared between different nonmetal atoms
- Examples:
  $O-Cl$  $O-S$  $N-Cl$

Bond Polarity: Ionic

Ionic bond
- Electrons are transferred between metal and nonmetal atoms
- $NaCl$  $KF$
Learning Check
Identify the type of bond between the following atoms
A. K-N
   1) nonpolar  2) polar  3) ionic
B. N-O
   1) nonpolar  2) polar  3) ionic
C. Cl-Cl
   1) nonpolar  2) polar  3) ionic

Solution
A. K-N  3) ionic
B. N-O  2) polar
C. Cl-Cl  1) nonpolar

Polyatomic Ions
A group of atoms with an overall charge.
NH₄⁺  ammonium
OH⁻  hydroxide
NO₃⁻  nitrate
NO₂⁻  nitrite
CO₃²⁻  carbonate
HCO₃⁻  hydrogen carbonate (bicarbonate)

More Polyatomic Ions
Sulfur
SO₄²⁻  sulfate
SO₃²⁻  sulfite
HSO₃⁻  hydrogen sulfate
H₂SO₃  hydrogen sulfite
Phosphate
PO₄³⁻  phosphate
PO₃³⁻  phosphite
HPO₄²⁻  dihydrogen phosphate
H₂PO₄⁻  hydrogen phosphate

Naming Ternary Compounds
- Contain at least 3 elements
- Name the nonmetals as a polyatomic ion
- Examples:
  NaNO₃  Sodium nitrate
  K₂SO₄  Potassium sulfate
  Al(HCO₃)₃  Aluminum bicarbonate
             or
             Aluminum hydrogen carbonate

Learning Check
Match each set with the correct name:
A. Na₂CO₃
   1) magnesium sulfite
   MgSO₃
   2) magnesium sulfate
   MgSO₄
   3) sodium carbonate
B. Ca(HCO₃)₂
   1) calcium carbonate
   CaCO₃
   2) calcium phosphate
   Ca₃(PO₄)₂
   3) calcium bicarbonate
Solution

A. \( \text{Na}_2\text{CO}_3 \)
   3) sodium carbonate

\( \text{MgSO}_3 \)
   1) magnesium sulfite

\( \text{MgSO}_4 \)
   2) magnesium sulfate

B. \( \text{Ca(HCO}_3\text{)}_2 \)
   3) calcium bicarbonate

\( \text{CaCO}_3 \)
   1) calcium carbonate

\( \text{Ca}_3\text{(PO}_4\text{)}_2 \)
   2) calcium phosphate

Learning Check

A. aluminum nitrate
   1) \( \text{AlNO}_3 \)
   2) \( \text{Al(NO)}_3^2 \)
   3) \( \text{Al(NO)}_3^3 \)

B. copper(II) nitrate
   1) \( \text{CuNO}_3 \)
   2) \( \text{Cu(NO)}_3^2 \)
   3) \( \text{Cu}_2\text{(NO)}_3 \)

C. iron (III) hydroxide
   1) \( \text{FeOH} \)
   2) \( \text{Fe}_3\text{OH} \)
   3) \( \text{Fe(OH)}_3 \)

D. tin(IV) hydroxide
   1) \( \text{Sn(OH)}_4 \)
   2) \( \text{Sn(OH)}_2 \)
   3) \( \text{Sn}_4\text{(OH)} \)