Elements and Chemical Bonds

Chapter 11
Essential Question

How does understanding periodic trends allow us to predict properties of different elements?
Vocabulary

- Ionic bond
- Covalent bond
Compounds, Chemical Formulas, and Covalent Bonds
From Elements to Compounds

Compare making cupcakes to compounds....
Compounds are substances made up of two or more different elements.

While an element is made of one type of atom, a compound is a chemical combination of different types of atoms.

Compounds and the elements that make them up often have different properties.

These atoms are joined together by chemical bonds.

Chemical bonds are forces that hold atoms together in a compound.
Quick Check

How is a compound different from the elements that compose it?
Covalent Bonds - Electron Sharing

- A covalent bond is a chemical bond formed when two atoms share one or more pairs of valence electrons.
  - Occurs between nonmetal atoms
  - This allows the atom to then form a stable covalent compound.
  - Most atoms are chemically stable with eight valence electrons; therefore, an atom with less than eight valence electrons becomes stable by forming chemical bonds until it has reached the necessary limit.
  - Ex: an oxygen atom would need to form two bonds in order to become stable.

H:H
H - H

A covalent bond is a chemical bond formed when two atoms share one or more pairs of valence electrons.
Covalent Bonds-Electron Sharing

Shared Electrons

- Once the oxygen atom shares its unpaired valence electrons with hydrogen, they begin to form two covalent bonds and become a stable covalent compound.

- Each covalent bond contains two valence electrons, one from each atom.

- Since the electrons are being shared, they will count as valence electrons for both atoms in the bond.

Ex: $\text{H}_2\text{O}$
Double and Triple Covalent Bonds

- A single covalent bond exist when two atoms share one pair of valence electrons; however, a double covalent bond exits when two atoms share two pairs of valence electrons.
- A triple bond exist when two atoms share three pairs of valence electrons.
- Double bonds are stronger than single bonds, and triple bonds are stronger than double bonds.
A

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{Cl} & \quad \text{Cl}
\end{align*}
\]

B

\[
\begin{align*}
\text{O} & \quad \text{O} \\
\text{O} & \quad \text{C} \quad \text{O}
\end{align*}
\]

C

\[
\begin{align*}
\text{N} & \quad \text{N}
\end{align*}
\]
Covalent compounds consist of two or more atoms sharing valence electrons. Some common properties include:

- Low melting points
- Low boiling points
- Gas or liquid at room temperature
- Poor conductors of thermal energy and electricity
- Ex: water, carbon dioxide, and sugar
Covalent Compounds

- Molecules are chemically stable units of a covalent compound.
  - A molecule can be defined as “a group of atoms held together by covalent bonding that acts as an independent unit”.
  - Ex: Table sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$)
    - Contains 12 carbon atoms, 22 hydrogen atoms, 11 oxygen atoms
  - One grain of sugar is composed of trillions of sugar molecules, the only way to break down the molecule would be to chemically separate the carbon, hydrogen, and oxygen atoms.
What are some common properties of covalent compounds?
Polar Molecules

- Polar molecules are molecules that have a partial positive end and a partial negative end because of unequal sharing of electrons.
  - Ex: water
  - In water, the oxygen atom attracts the shared electrons more strongly than each hydrogen does; causing the shared electrons to be pulled closer to the oxygen atom. Leaving the oxygen with a partial negative charge and the hydrogen with a partial positive charge.

- ONLY POLAR MOLECULES CAN DISSOLVE IN POLAR SOLUTIONS!!!
  - Ex: sugar can easily dissolve into water
  - Explain how you think this occurs…
Nonpolar Molecules

- **REMEMBER…**
  
  ”LIKE DISSOVLES LIKE”!!!!

- When a molecule is paired with itself, H$_2$ for instance, the molecule is said to be nonpolar, because the atoms are identical and their attraction for the shared element is equal.

- Carbon dioxide also posses characteristics, which classifies the molecule as nonpolar.

- Nonpolar molecules do not easily dissolve in polar compounds, but they do dissolve in nonpolar compounds.
Chemical Formulas and Molecular Models

A chemical formula is a group of chemical symbols and numbers that represent the elements and the number of atoms of each element that make up a compound.

Just as a recipe lists ingredients, a chemical formula lists the elements in a compound.

The formula uses chemical symbols that show which elements are in the compound. The subscript (small number after a chemical symbol), show the number of atoms of each element in the compound.

Chemical formulas describes the type of atoms in a compound or molecule, however, it does not explain the shape or appearance of the molecule.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Molecular Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>C₆H₁₂O₆</td>
</tr>
<tr>
<td>Butane</td>
<td>C₄H₁₀</td>
</tr>
<tr>
<td>Octane</td>
<td>C₈H₁₈</td>
</tr>
</tbody>
</table>
Quick Check

What information is given in a chemical formula?
Ionic and Metallic Bonds
Understanding Ions

- When a metal and a nonmetal bond, they do not share electrons; instead, one or more valence electrons are transferred, creating a chemical bond between the stable compound.

- Once an atom loses or gains an electron, it becomes an ion.
  - An ion is an atom that is no longer electrically neutral because it has lost or gained valence electrons.
  - This changes the overall charge of the atom.
  - Atoms that lose electrons become positive, atoms that gain electrons become negative.
  - Explain why this is the case.....
Losing Valence Electrons

Look at sodium (Na) on the periodic table, what information can you infer about the element.

- Metal
- Atomic number is 11 (11 protons, 11 electrons & 11 neutron)
- Group 1
- Chemically unstable
Metal atoms, such as sodium, become more stable when they lose valence electrons and form a chemical bond with a nonmetal.

The atom now has the eight valence electrons, making it chemically stable and a positive charge.
Gaining Valence Electrons

- Nonmetals atoms have the capability to gain electrons from metal atoms, helping them to gain the electron arrangement of a noble gas.

- Chlorine (Cl) atomic number is 17, giving the atom 7 valence electrons. If chlorine gains one valence electron, it will become chemically stable and give it the arrangement of a noble gas.
Quick Check

- Are atoms of a group 16 element more likely to gain or lose valence electrons?
Ionic Bonds - Electron Transferring

- REMEMBER…METAL ATOMS LOSE VALENCE ELECTRONS AND NONMETAL ATOMS GAIN VALENCE ELECTRONS.

- Look at the chemical formula for table salt (NaCl)

- Together, the two ions form an ionic compound.
Ionic Compound

- Characteristics of ionic compound:
  - Solid and brittle at room temperature
  - High melting point
  - High boiling point
  - Dissolve in water
  - Good conductor of electricity

- The attraction between positively and negatively charged ions in an ionic compound is an ionic bond.
Ionic vs. Covalent

- **Covalent Compounds**
  - Two or more nonmetal atoms share electrons and form a molecule.
  - Made of many molecules.

- **Ionic Compounds**
  - Nonmetal ion bond to metal ions and form an ionic compound.
  - No molecules.
  - Large collection of oppositely charged ions held together by ionic bonds.
Metallic Bonds - Electron Pooling

What happens when metal atoms bond to other metal atoms?
Metal atoms form compounds with one another by combining, or pooling their valence electrons.

*Metallic pooling is a bond formed when many metal atoms share their pooled valence electrons.*

The atoms lose their valence electrons and become positive ions. The negative ion then move from ion to ion.

This is due to the fact valence electrons are not bonded to the atom in metals, instead, a “sea of electrons” surround the positive ions.
Valence electrons are free to move among all the aluminum (Al) ions.
## Properties of Metallic Compounds

<table>
<thead>
<tr>
<th>Type of Bond</th>
<th>What is bonding?</th>
<th>Properties of Compounds</th>
</tr>
</thead>
</table>
| Covalent—share valence electrons | nonmetal atoms; nonmetal atoms | • gas, liquid, or solid  
• low melting and boiling points  
• often not able to dissolve in water  
• poor conductors of thermal energy and electricity  
• dull appearance |
| Ionic—transfer valence electrons | nonmetal ions; metal ions | • solid crystals  
• high melting and boiling points  
• dissolves in water  
• solids are poor conductors of thermal energy and electricity  
• ionic compounds in water solutions conduct electricity |
| Metallic—pool valence electrons | metal ions; metal ions | • usually solid at room temperature  
• high melting and boiling points  
• do not dissolve in water  
• good conductors of thermal energy and electricity  
• shiny surface  
• can be hammered into sheets and pulled into wires |