

COVALENT BONDS

Covalent bonds are a fundamental concept in chemistry, playing a crucial role in the formation of molecules. It plays a crucial role in the chemistry of everyday substances like water, carbon dioxide, sugars, fats, proteins, and DNA.

Molecular Formula (Libretexts, 2022)

A molecular formula uses chemical symbols and numbers to show a molecule's composition. It gives crucial details on a molecule's composition and structure by indicating the kinds and quantities of atoms that make up the molecule.

The formula consists of the chemical symbols of the elements present in the molecule, followed by subscripts that indicate the number of each type of atom.

For example:	water	H_2O	2 Hydrogen atoms (H) and 1 oxygen atom (O)
	Sulfuric acid	H_2SO_4	2 Hydrogen, 1 Sulfur and 4 Oxygen atoms

Empirical Formula

This shows the simplest whole-number ratio of the elements in a compound.

For example:	hydrogen peroxide	HO	1 Hydrogen per 1 Oxygen
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Molecular Formula: This provides the actual number of atoms of each element in a molecule.

For example:	hydrogen peroxide	H_2O_2
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Lewis Structure of Molecular Compounds

Lewis Structure is a useful tool in chemistry for depicting the arrangement of electrons and the bonds between atoms in a molecule and the arrangement of electrons.

Valence electrons

A useful tool in chemistry for depicting the arrangement of electrons and the bonds between atoms in a molecule.

Steps:

1. Count Valence Electrons: Add up the total number of valence electrons from all atoms in the molecule.
2. Determine the Central Atom: Usually, the least electronegative atom (excluding hydrogen) is placed in the center.
3. Connect Atoms: Use single bonds to connect the central atom to surrounding atoms.
4. Distribute Remaining Electrons: Place the remaining electrons around the outer atoms to satisfy the octet rule (eight electrons for most atoms).
5. Form Multiple Bonds if Necessary: If any atoms do not have an octet, consider forming double or triple bonds by sharing pairs of electrons.

Compound	Empirical Formula	Molecular Formula	Structure
Acetic acid		C ₂ H ₄ O ₂	
Glucose	CH ₂ O	C ₆ H ₁₂ O ₆	

Covalent Compounds (Chang, 2024)

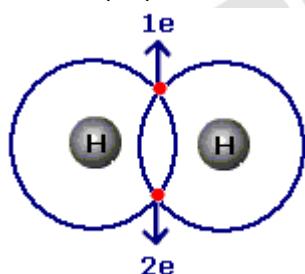
A covalent bond is a type of chemical bond where two atoms share one or more pairs of electrons. This sharing allows each atom to attain the electron configuration of a noble gas, leading to greater stability.

Covalent Bonding Formation

- Covalent bonds arise from the sharing of electrons between two (2) atoms.
- Follows the octet rule requiring all atoms in a molecule to have eight (8) valence electrons by sharing to become stable
- Covalent bonds form when two (2) nonmetallic atoms have the same or similar electronegativity values.
- Each single covalent bond consists of two (2) shared electrons. Double covalent bonds possess four (4) shared electrons and triple covalent bonds have six (6) shared electrons.

Examples:

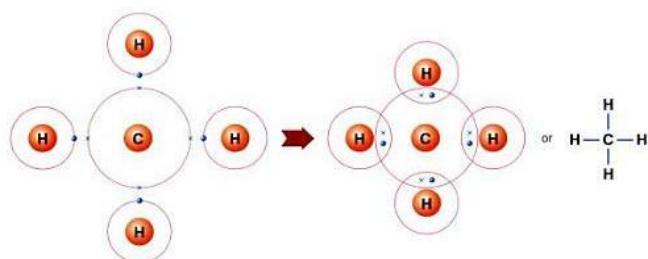
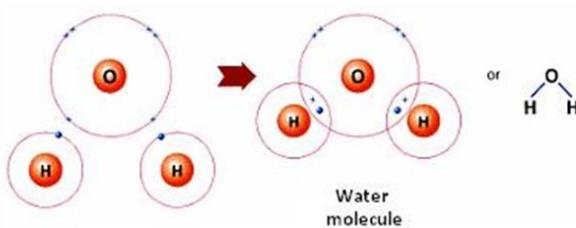
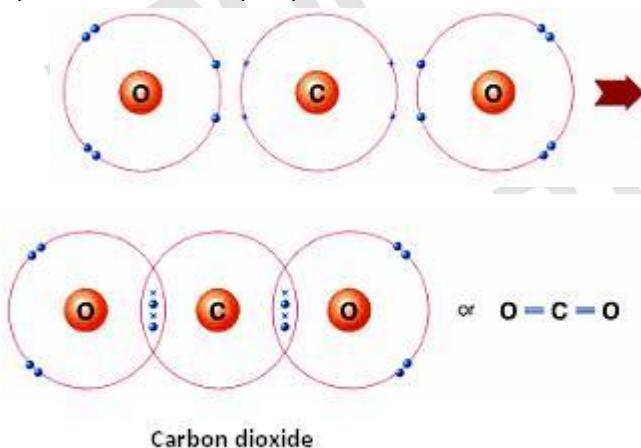
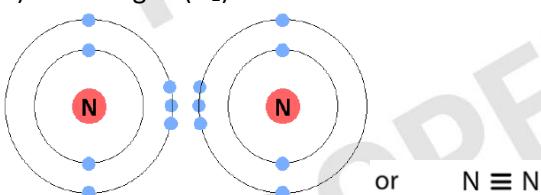
1) Hydrogen Molecule (H₂)



- Electrons are present in the K shell of the hydrogen atom.
- Two (2) identical nonmetals bond together, forming a pure covalent bond.

2) Methane molecule (CH₄)

- The electronic configuration of carbon is 2,4 ($1s^2 2s^2 2p^2$). It needs four (4) more

3) Water molecule (H_2O)4) Carbon dioxide (CO_2)5) Dinitrogen (N_2)

electrons in its outer shell to be like the noble gas neon. To do this, one (1) carbon atom shares four (4) electrons with the single electrons from four (4) hydrogen atoms.

- The methane molecule has four C-H single bonds.
- One (1) oxygen atom joins with two (2) hydrogen atoms.
- The water molecule has two (2) O-H single bonds.

- One (1) carbon atom joins with two (2) oxygen atoms.
- The carbon dioxide molecule has two (2) C=O bonds.

- The dinitrogen molecule has a triple bond and two (2) lone pairs, respectively, to suffice the octet rule.
- Pure covalent bond since two (2) identical atoms interact.

Naming Covalent Compounds

Guidelines:

- 1) The first element is simply written as is.
- 2) The second element is named by taking the stem of the element and adding *-ide*.
- 3) A prefix is added to specify the number of atoms in a molecule.

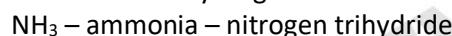
- 4) If the second element is oxygen, the vowel is usually omitted. (monoxide, dioxide, trioxide.)

Examples:



- 5) Some compounds have common names that are usually used. These compounds have systematic names that are usually used in translating chemical equations.

Examples:



Electronegativity and Polarity of Covalent Bonds

Bond polarities arise from bonds between atoms of different electronegativity. Polar bonds are treated as vectors (with both direction and magnitude) pointing from the positively charged atom to the negatively charged atom. The size of the vector is proportional to the difference in electronegativity of the two (2) atoms. If the two (2) atoms are identical, the magnitude of the vector is zero and the bond is nonpolar.

Predicting Molecular Polarity

1. Draw a Lewis structure with correct geometry and identify each bond as either polar or nonpolar.
 2. The molecule is nonpolar if:
 - a. No polar bond exists.
 - b. Central atoms have no lone pair, and all bonded atoms are the same ($\text{BF}_3/\text{CF}_4/\text{PF}_5/\text{SF}_6$).
 - c. Arrangement symmetrical with vector arrows (electronegativity differences) of equal length.
 - d. The sum of vectors is equal to zero.
 3. The molecule is polar if vector arrows do not cancel.

Examples:

A. Polar Molecules

H_2O		
SO_2		
IF_3		

B. Non-Polar Molecules

Compound	Lewis Diagram	Bond Dipole
C_2H_2	$\text{H} : \text{C} :: \text{C} : \text{H}$	
C_2H_4		

CH_4	$\begin{array}{c} \text{H} \\ \cdot\cdot \\ \text{H} : \text{C} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$	<p>The Lewis structure shows a central carbon atom (C) bonded to four hydrogen atoms (H), with two lone pairs of electrons above and below the plane of the page. The 3D ball-and-stick model shows a central carbon atom bonded to four hydrogen atoms, with the bonds represented by sticks and the atoms by spheres.</p>
SO_3	<p>The Lewis structure shows a central sulfur atom (S) bonded to three oxygen atoms (O), with one double bond and one single bond, and three lone pairs of electrons above and below the plane of the page.</p>	<p>The 3D ball-and-stick model shows a central sulfur atom (S) bonded to three oxygen atoms (O) in a trigonal pyramidal arrangement. Blue arrows indicate the direction of electron movement or flow from the oxygen atoms towards the central sulfur atom.</p>

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