

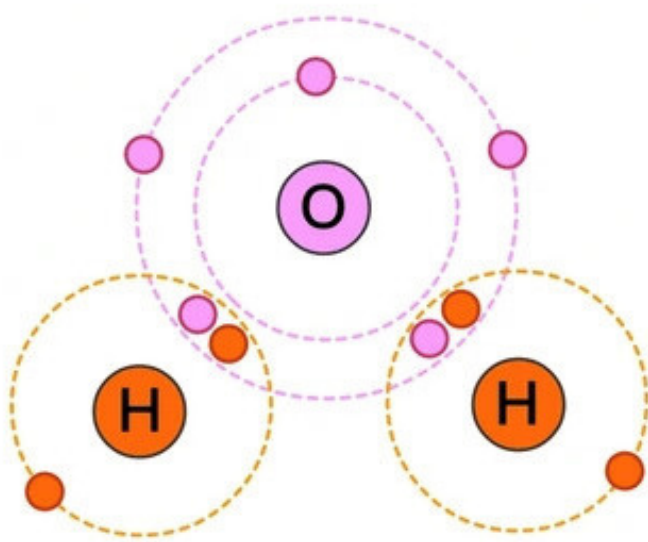
COVALENT BONDING – GCSE CHEMISTRY

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1. Introduction

- Covalent bonding is a type of chemical bond where two atoms share one or more pairs of electrons to achieve stability.
- This bond typically forms between nonmetal atoms that have similar electronegativities, meaning neither atom can completely transfer electrons to the other (as in ionic bonding).
- **Example:** Water (H_2O) has polar covalent bonds, making it essential for life.



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2. How Covalent Bonds are formed?

Covalent bonds are created when two nonmetal atoms share electrons to complete their outer electron shells. Here's how it happens:

Step-by-Step Formation:

Step#1: Atoms Approach Each Other

- Two nonmetal atoms (e.g., hydrogen, oxygen, carbon) move close together.
- Each atom has an incomplete outer electron shell and seeks stability.

Step#2: Valence Electrons Interact

- The valence electrons (outermost electrons) of each atom begin to feel the attraction from the other atom's nucleus.
- Example: Two hydrogen atoms (each with 1 electron) start to share their electrons.

Step#3: Electron Sharing Begins:

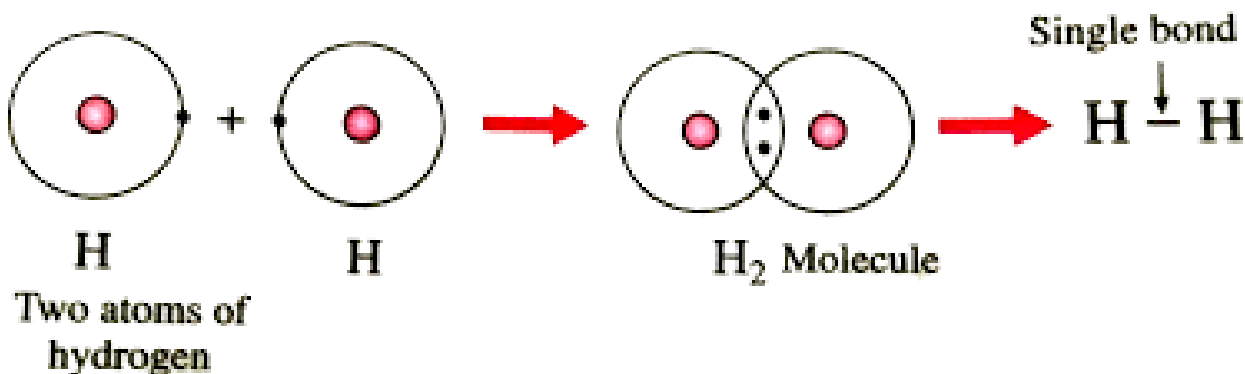
- The atoms overlap their atomic orbitals, creating a shared region where electrons move around both nuclei.
- This forms a bonding molecular orbital, where the electrons are most likely to be found.

Example: Formation of a Hydrogen Molecule (H₂)

- Two hydrogen atoms (each with **1 electron**) approach each other.
- Their **1s orbitals overlap**, and the electrons pair up.
- The shared electrons now occupy the space between the nuclei.
- A **single covalent bond (H–H)** is formed.

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Diagrammatically, it can be represented as:



3. Formation of Covalent Compounds.

- **Occurs Between:** Non-metal atoms (e.g., H, O, C, N) needing electrons.
- **Process:**
 - Atoms share valence electrons to complete their outer shells
 - Each shared pair forms one covalent bond
 - Can form single (1 pair), double (2 pairs), or triple (3 pairs) bonds
- **Result:**
 - Creates discrete molecules (e.g., H₂O, CO₂)
 - Molecules have specific 3D shapes (determined by VSEPR theory)
- **Key Properties:**
 - Low melting/boiling points
 - Poor electrical conductors
 - Often gases/liquids at room temperature

Example: Two hydrogen atoms share electrons → H₂ molecule

Covalent compounds make up most biological molecules and organic substances.

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4. Types of Covalent Compounds

Covalent compounds can be systematically categorized based on their structure, bonding characteristics, and physical properties. Here's an in-depth examination:

Types of Covalent compounds:

1. Simple Molecular Compounds

- **Characteristics:**

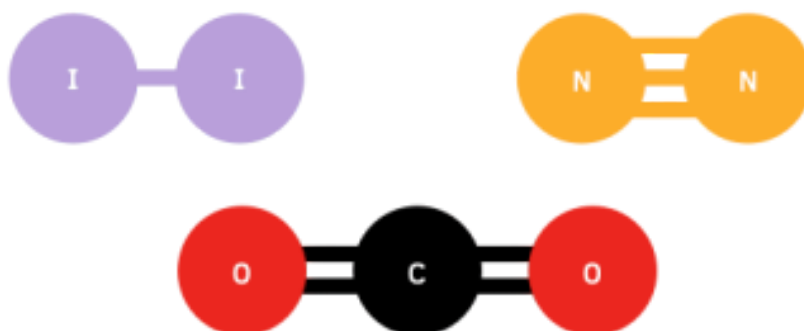
- Discrete molecules held by strong intramolecular bonds but weak intermolecular forces
- Typically low melting/boiling points
- Often volatile at room temperature
- Poor electrical conductors
- Subcategories:

- **a) Diatomic Molecules**

- Contain exactly two identical atoms
- Examples: N_2 (nitrogen), Cl_2 (chlorine), I_2 (iodine)

- **b) Polyatomic Molecules**

- Contain three or more atoms
- Examples: H_2O (water) - bent structure, 104.5° bond angle



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2. Giant Covalent (Macromolecular) Structures

- **Characteristics:**

- Three-dimensional network of covalently bonded atoms
- Exceptionally high melting/boiling points
- Generally insoluble in all solvents
- Variable electrical conductivity

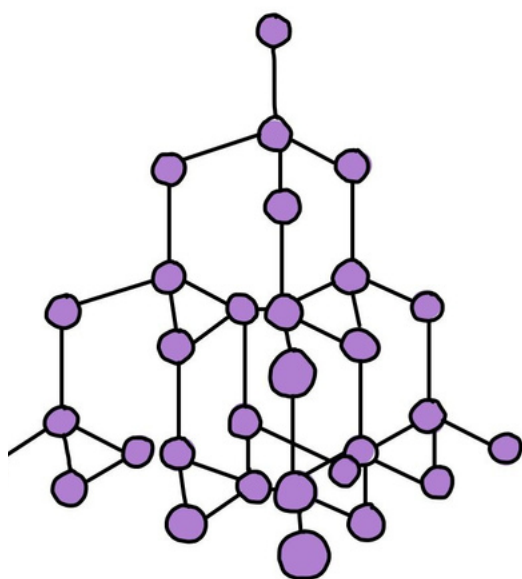
- **Notable Examples:**

Diamond

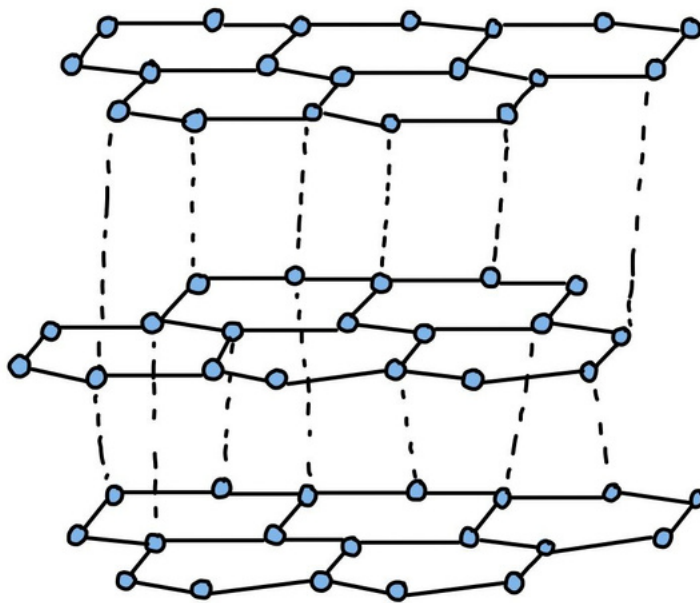
- Each carbon forms 4 tetrahedral bonds
- Hardest known natural material
- Excellent thermal conductor but electrical insulator

Graphite

- Layered



DIAMOND



GRAPHITE

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5. Properties of Covalent Compounds.

Covalent compounds exhibit distinct physical and chemical properties that stem from their molecular structure and bonding characteristics.

1. Physical State

- **Molecular Form:** Typically exist as gases, liquids, or low-melting solids at room temperature
 - Examples:
 - Gases (O_2 , CO_2), Liquids (H_2O , C_6H_6 benzene), Soft solids (I_2),
- **Network Solids:** Exceptionally hard, high-melting materials
 - Examples: Diamond (3550°C), silicon carbide (2700°C)

2. Electrical Conductivity

- **Poor conductors** in all states
 - Exception: Graphite (conducts within layers)
 - Some become conductive when dissolved (e.g., HCl in water)
- **Semiconductors:** Special category (Si , GaAs) with tunable conductivity.

3. Solubility

- Poor conductors in all states
 - **Exception:** Graphite (conducts within layers)
 - Some become conductive when dissolved (e.g., HCl in water)
- **Semiconductors:** Special category (Si , GaAs) with tunable conductivity.

4. Isomerism

- **Structural isomers:** Same formula, different connectivity
- **Stereoisomers:** Same connectivity, different spatial arrangement

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Difference between Ionic And Covalent Bonding.

IONIC BONDING	COVALENT BONDING
Ionic bonding occurs primarily between metals and non-metals due to their contrasting electronegativities.	Covalent bonding occurs when two non-metals share electrons to achieve stability.
Ionic bonds generally have high melting and boiling points.	Covalent bonds generally have low melting and boiling points.
Soluble in Polar solvents such as water .	Soluble in Non-Polar solvents such as benzene .
It conducts electricity when dissolved/melted .	These are poor conductors of heat and electricity (except polar solvents such as HCL).
These are usually solid or in crystalline form.	It can be liquid, solid, or gas .
Examples: NaCl and MgO	Examples: H ₂ O and CH ₄

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7. FAQs (Frequently Asked Questions)



1. What is a covalent compound?

A covalent compound is formed when two or more nonmetal atoms share electrons to achieve a stable electron configuration (usually an octet). Examples include H_2O (water), CO_2 (carbon dioxide), and CH_4 (methane).

2. Why do covalent compounds have low melting/boiling points?

Most covalent compounds exist as individual molecules held together by weak intermolecular forces (e.g., van der Waals forces, hydrogen bonds). These forces require less energy to break than ionic bonds.

3. Are covalent compounds soluble in water?

- Polar covalent compounds (e.g., sugar, ethanol) dissolve in water.
- Nonpolar covalent compounds (e.g., oil, methane) do not dissolve in water but dissolve in organic solvents like hexane.

4. Are all organic compounds covalent?

Yes! Organic compounds (e.g., methane, ethanol, DNA) are primarily made of C–H and C–C covalent bonds.

5. Why is diamond hard but graphite soft?

- Diamond: Each carbon is tetrahedrally bonded in a rigid 3D network.
- Graphite: Carbon atoms form layers that slide easily due to weak interlayer forces.

6. What is the difference between a molecule and a covalent compound?

- Molecule: Any group of bonded atoms (can be elements or compounds).
- Covalent compound: A substance made of molecules with different elements (e.g., H_2O , CO_2).