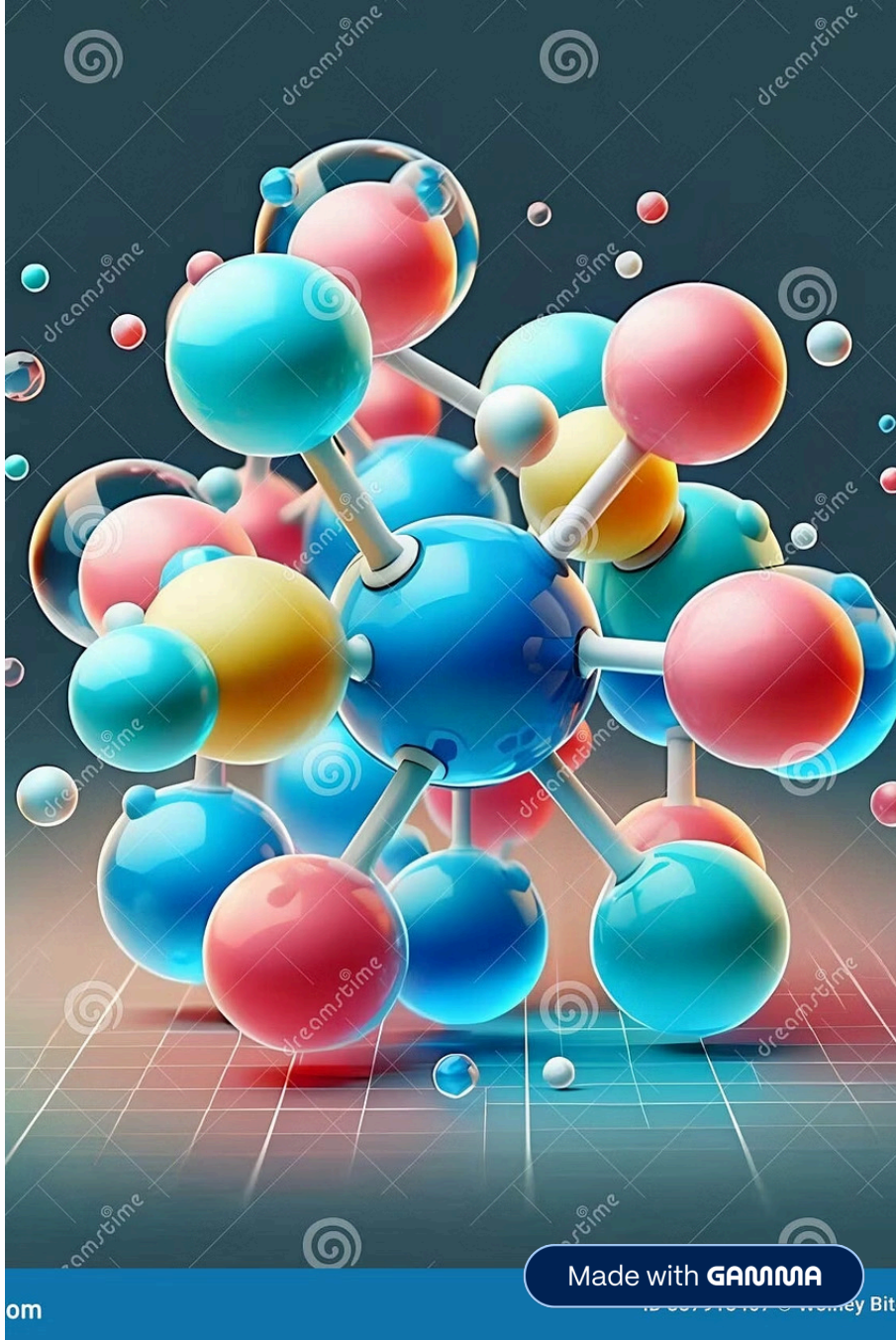
# The World of Chemical Bonding

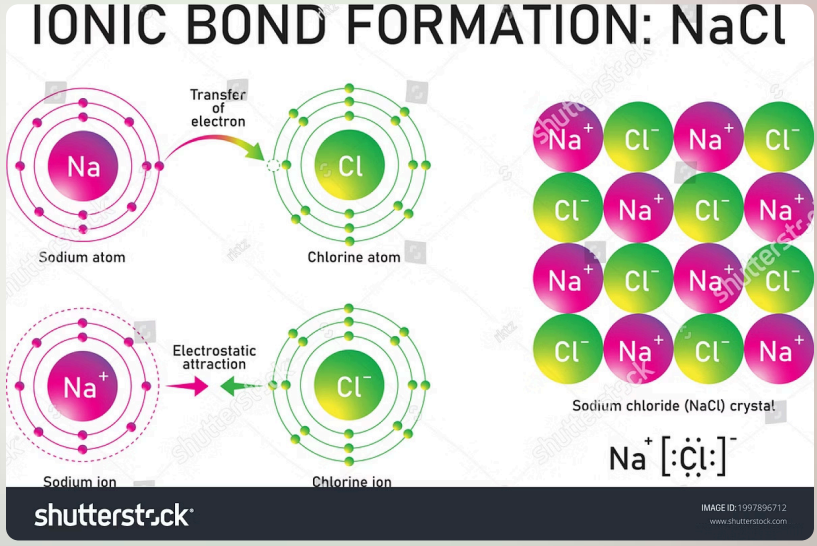
Explore the fundamental forces that hold matter together, from the salts on our tables to the very air we breathe.



# Chapter 2: Bonding & Structure

## (I) Ionic Bonding

Ionic bonding is an electrostatic attraction between positive and negative ions. It forms when a metal atom loses electrons to become a positive ion (cation) and a non-metal atom gains electrons to become a negative ion (anion). These oppositely charged ions then attract, forming a giant three-dimensional ionic structure.



# Formation of Ionic Bonds

01

## Metal Loses Electrons

Metal atom loses electrons, forming a positive ion (cation) with a stable electronic structure.

02

## Non-metal Gains Electrons

Non-metal atom gains electrons, forming a negative ion (anion) with a stable electronic structure.

03

## Opposite Attraction

These oppositely charged ions are attracted together by strong ionic bonds.

04

## Ionic Crystal Formation

The result is a giant three-dimensional ionic structure, like table salt (NaCl).

# Electronic Structure of Ions

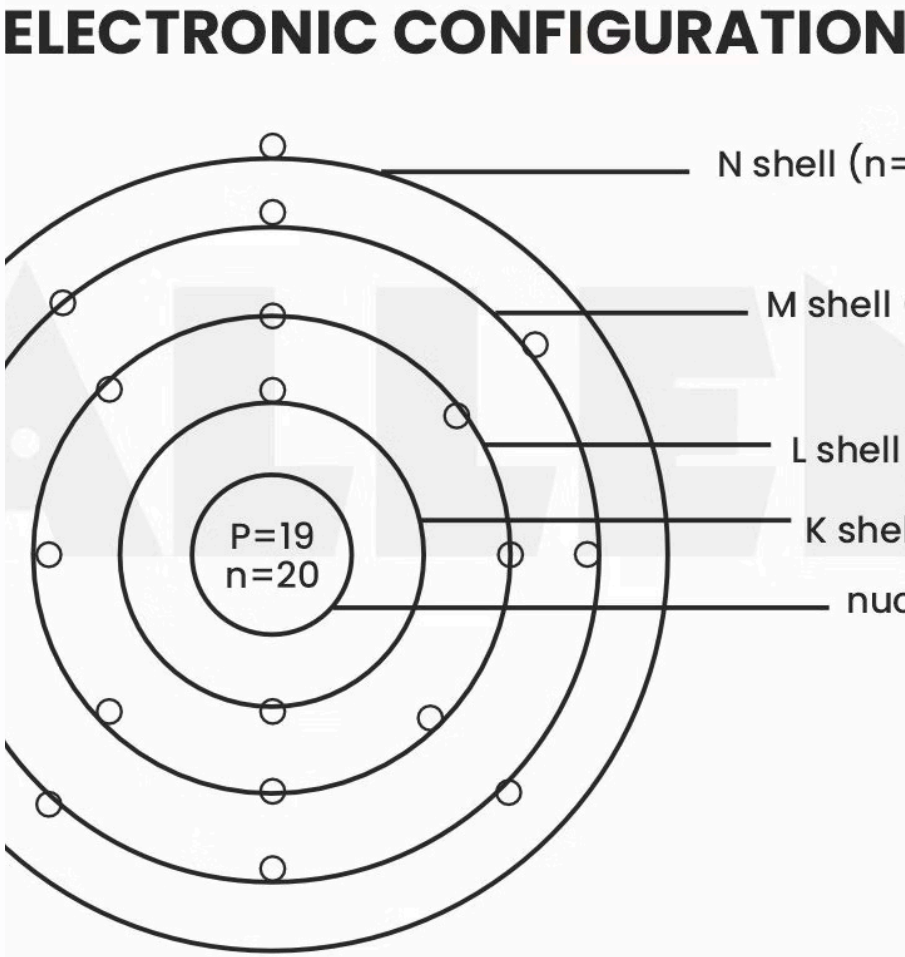
Atoms lose or gain electrons to achieve a stable electronic structure, similar to that of the nearest noble gas.

## Metals

Tend to have the structure of the noble gas before them. For example, Na atom (2,8,1) becomes Na+ ion (2,8), similar to Neon (Ne).

## Non-metals

Tend to have the structure of the noble gas after them. For example, Cl atom (2,8,7) becomes Cl- ion (2,8,8), similar to Argon (Ar).



# Properties of Ionic Compounds

### Solid at Room Temperature

Due to strong electrostatic attraction between ions.

### High Melting & Boiling Points

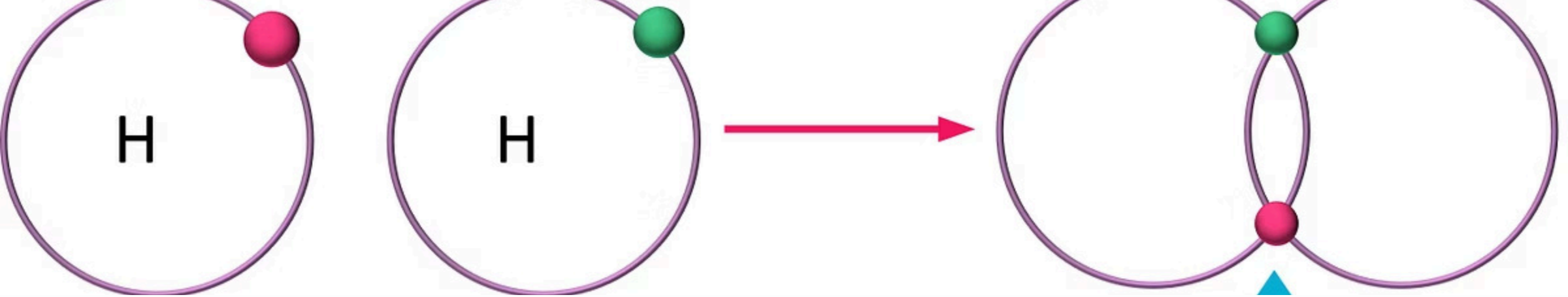
Requires significant energy to overcome strong ionic bonds.

### Poor Electrical Conductors (Solid)

Ions are not free to move in a solid state.

### Good Electrical Conductors (Molten/Aqueous)

Ions become mobile when melted or dissolved in water.




# (II) Covalent Bonding

Covalent bonding is an attraction force between non-metals formed by the sharing of electrons. This sharing leads to stable electronic configurations, often resembling noble gases.

## How it Forms

Two non-metal atoms each contribute an electron from their valence shell, and this pair is shared between them.

## Examples

Diatomic molecules like $H_2$, HCl, $N_2$, $O_2$, $F_2$, and $Cl_2$ are common examples of covalent bonds.

# Examples of Covalent Molecules

## Water ($H_2O$)

Central oxygen atom bonded to two hydrogen atoms.

## Methane ($CH_4$)

Central carbon atom bonded to four hydrogen atoms, tetrahedral shape.

## Carbon Dioxide ($CO_2$)

Double covalent bonds between carbon and each oxygen atom.

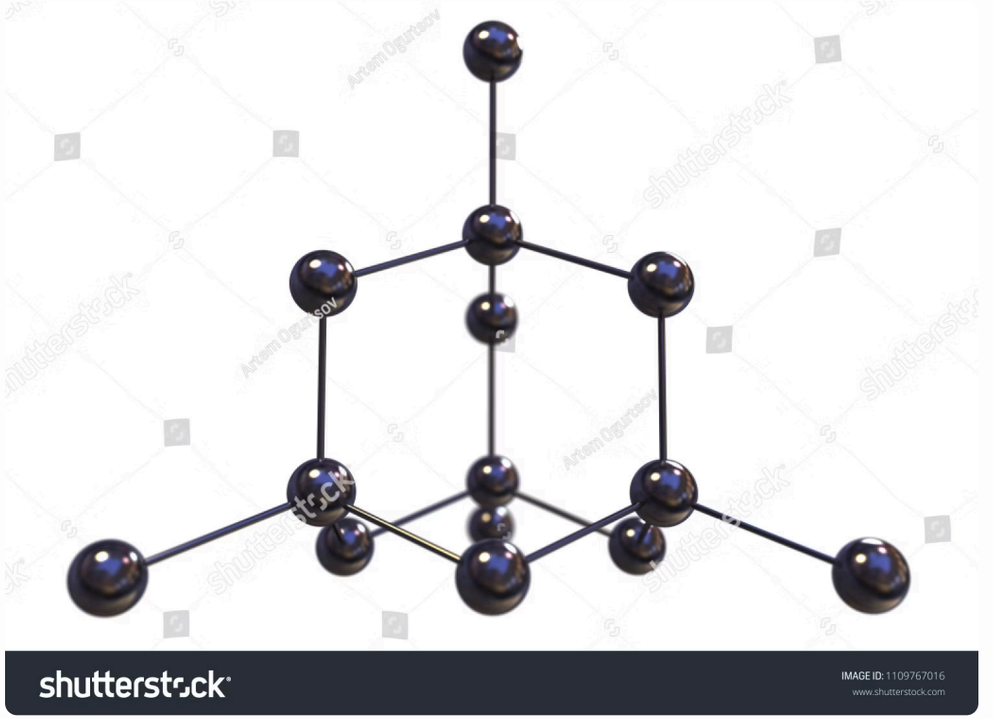
## Ammonia ($NH_3$)

Three bonding pairs and one lone pair around central nitrogen.

# Exceptions: Allotropes of Carbon

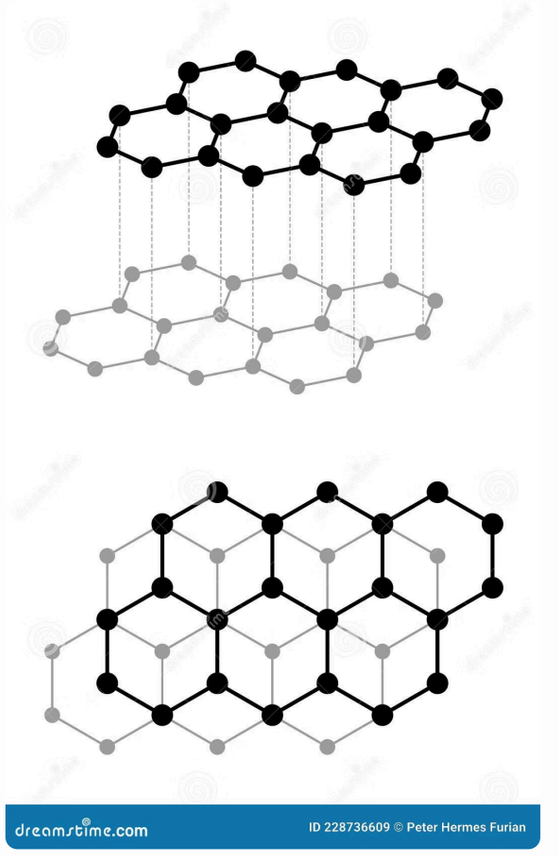
## Diamond

Repeated tetrahedral structure, each carbon bonded to four others. Very hard, high sublimation point, does not conduct electricity (no free electrons). Used for drilling and cutting.




## Graphite

Layers of repeated hexagons, each carbon bonded to three others within the layer. Weak forces between layers allow sliding (soft). Conducts electricity (free electrons). Used as lubricant and in pencils.



# (III) Metallic Bonding & Structure

Metallic bonding involves a lattice of positive metal ions embedded in a "sea of negative electrons," held together by electrostatic attraction.

## Solid at Room Temp

(Except mercury) due to strong metallic bonds.

## Good Electrical Conductors

Thanks to free-moving electrons.

## Malleable & Ductile

Layers of atoms can slide over each other due to weak metallic bonds.

# Alloys: Enhanced Properties

Alloys are mixtures of metals, often with superior properties like higher strength and rust resistance compared to pure metals.

| | | |
|---|---|---|
| Mild Steel | Iron, 0.2% carbon | Car bodies, ships, reinforced concrete |
| Stainless Steel | Iron, chromium, nickel, carbon | Chemical factories, cutlery, surgical equipment |
| Brass | Copper, zinc | Ornaments, statues, screws |