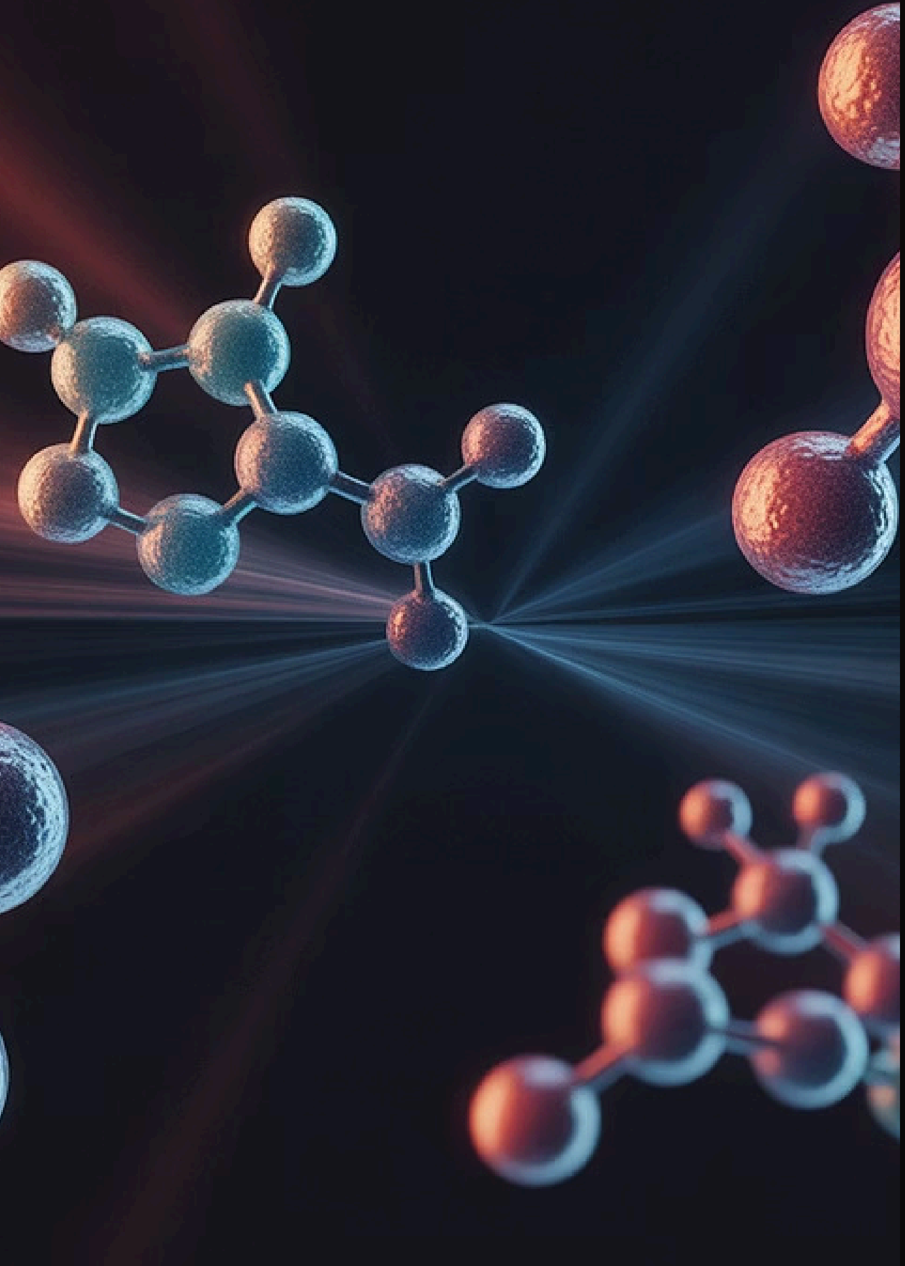


Chemistry Fundamentals

Lecture 12: Molecular Compounds

Mohamed Kamal

Molecular Compounds: Covalent Networks

Definition & Composition

Compounds formed by covalent bonding between nonmetal atoms, creating discrete molecules held together by intermolecular forces. Unlike ionic compounds, they share electrons rather than transferring them.

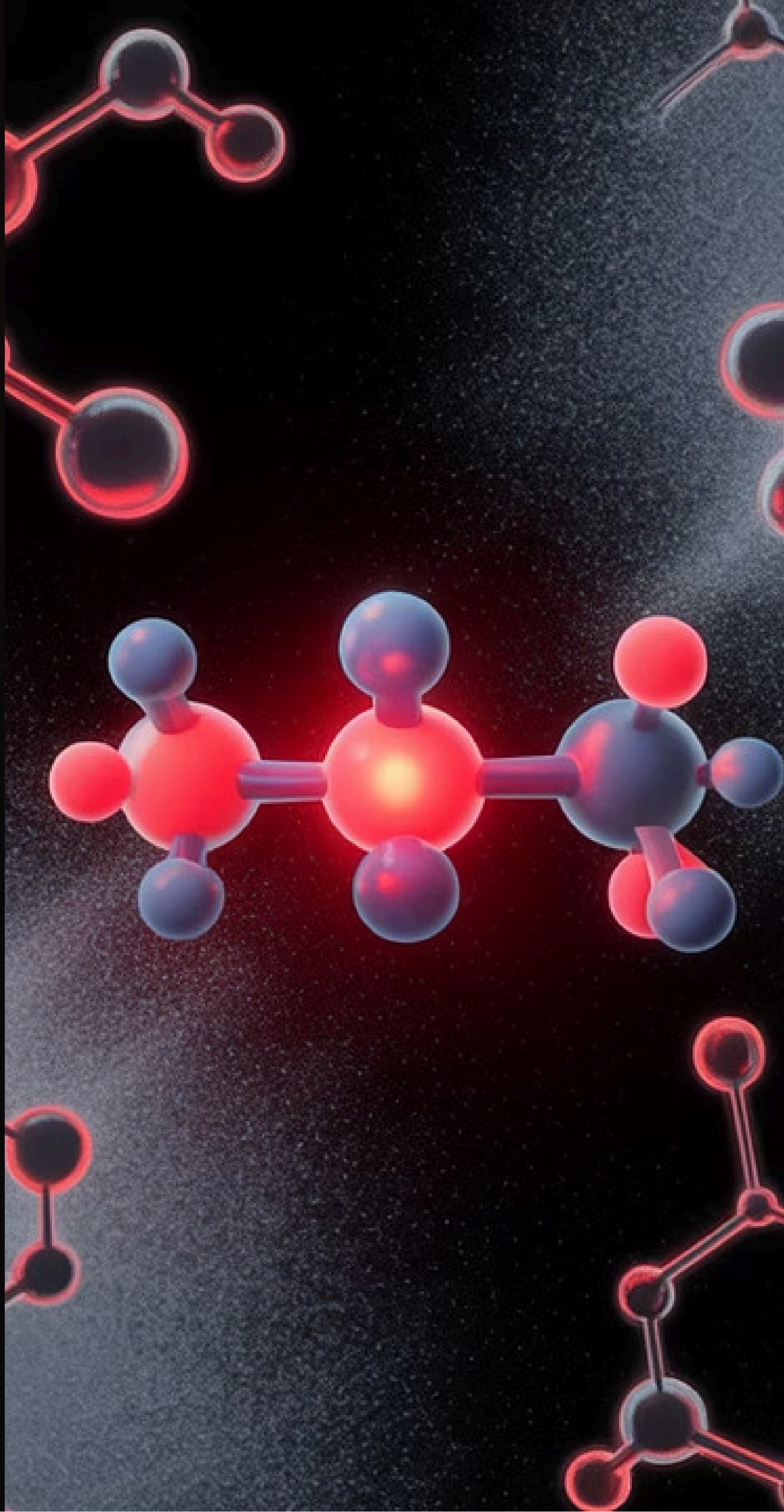
Examples & Formula

Common examples include H_2O, CO_2, CH_4, NH_3, and $C_6H_{12}O_6$. The molecular formula shows the actual number of atoms in each molecule.

Key Properties

- Lower melting/boiling points than ionic compounds
- Poor electrical conductors
- Often gases or liquids at room temperature
- Can be polar or nonpolar

Most organic compounds are molecular in nature.



Naming Binary Molecular Compounds

Naming Rules

1. First element: Use full element name
2. Second element: Use root name + "-ide" suffix
3. Use prefixes to indicate number of atoms

Special Rules:

- Omit "mono-" for first element
- Drop final vowel before vowel (monoxide not monooxide)

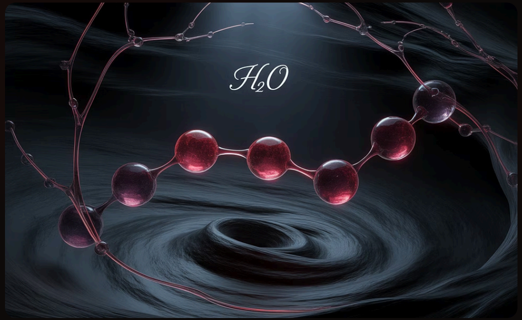
Prefixes

1: mono-	6: hexa-
2: di-	7: hepta-
3: tri-	8: octa-
4: tetra-	9: nona-
5: penta-	10: deca-

Examples

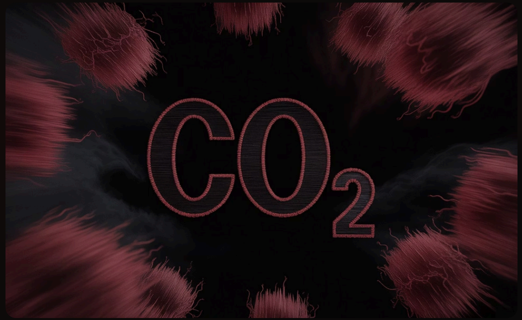
- CO: carbon monoxide
- CO_2: carbon dioxide
- N_2O_4: dinitrogen tetroxide
- PCl_5: phosphorus pentachloride

Common Molecular Compounds and Their Properties



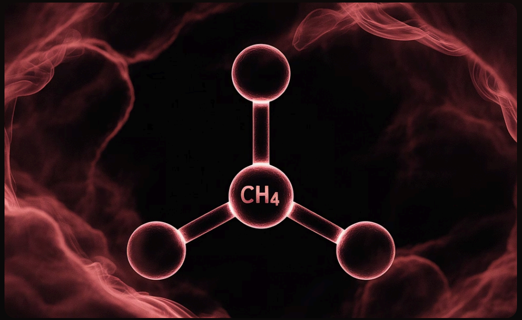
Water (H_2O)

- Bent molecular geometry
- Polar molecule with hydrogen bonding
- Universal solvent, high boiling point



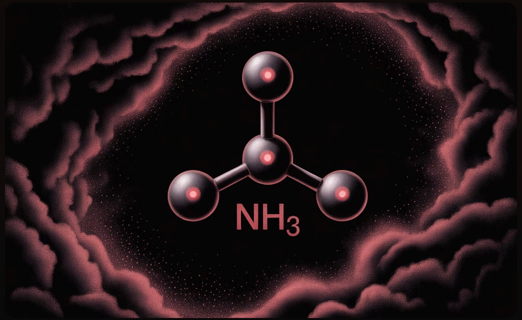
Carbon Dioxide (CO_2)

- Linear molecular geometry
- Nonpolar molecule despite polar bonds
- Greenhouse gas, dry ice when solid



Methane (CH_4)

- Tetrahedral molecular geometry
- Nonpolar molecule
- Main component of natural gas



Ammonia (NH_3)

- Pyramidal molecular geometry
- Polar molecule with hydrogen bonding
- Base in water, fertilizer ingredient

Molecular Formulas vs. Structural Information

Molecular Formula

Shows types and numbers of atoms (C_2H_6)

Structural Formula

Shows how atoms are connected

Condensed Formula

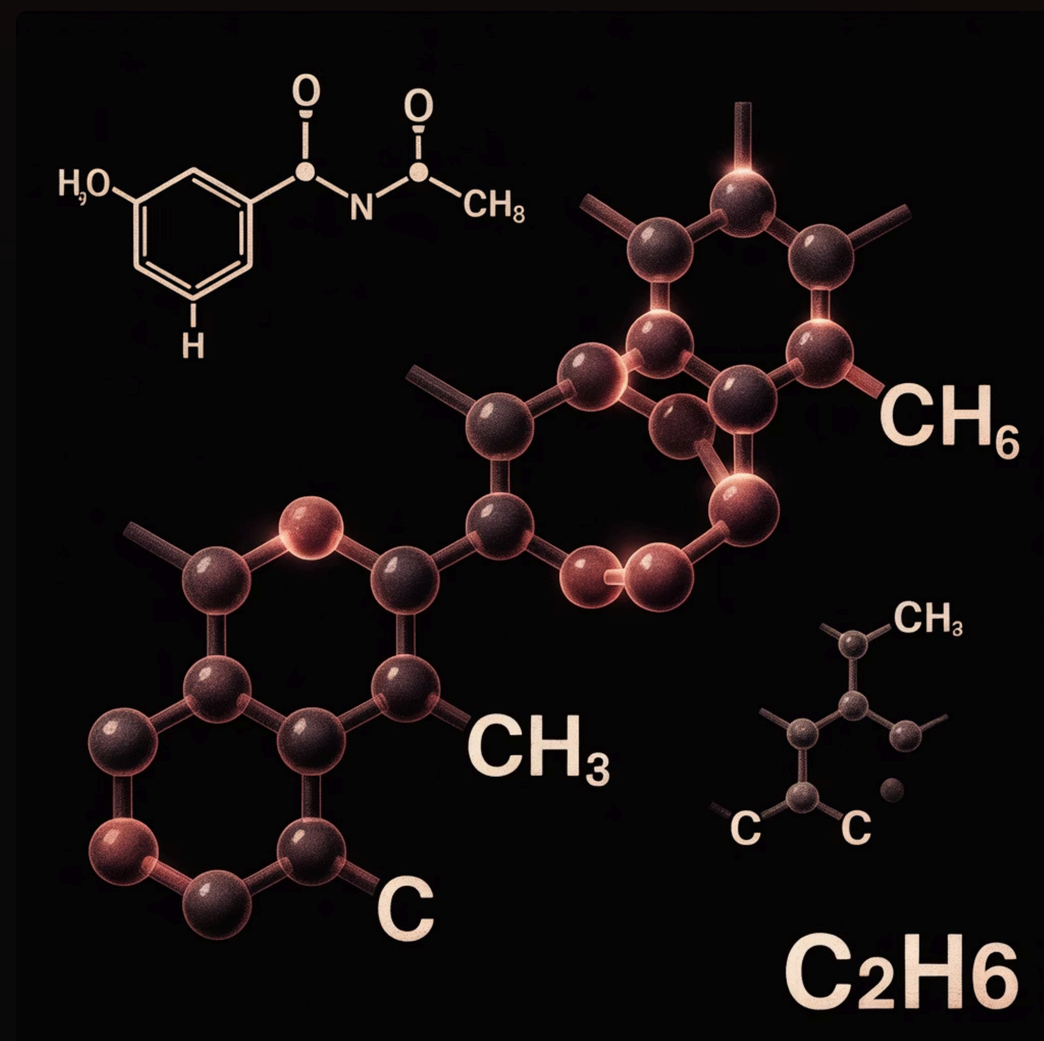
Simplified structural representation (CH_3CH_3)

Lewis Structure

Shows all valence electrons and bonds

Example: Ethane (C_2H_6)

- Molecular formula: C_2H_6
- Structural formula: H-C-C-H with all H atoms shown
- Condensed formula: CH_3-CH_3



Isomers: Different compounds with same molecular formula

Importance: Structure determines properties and reactivity

Polarity in Molecular Compounds

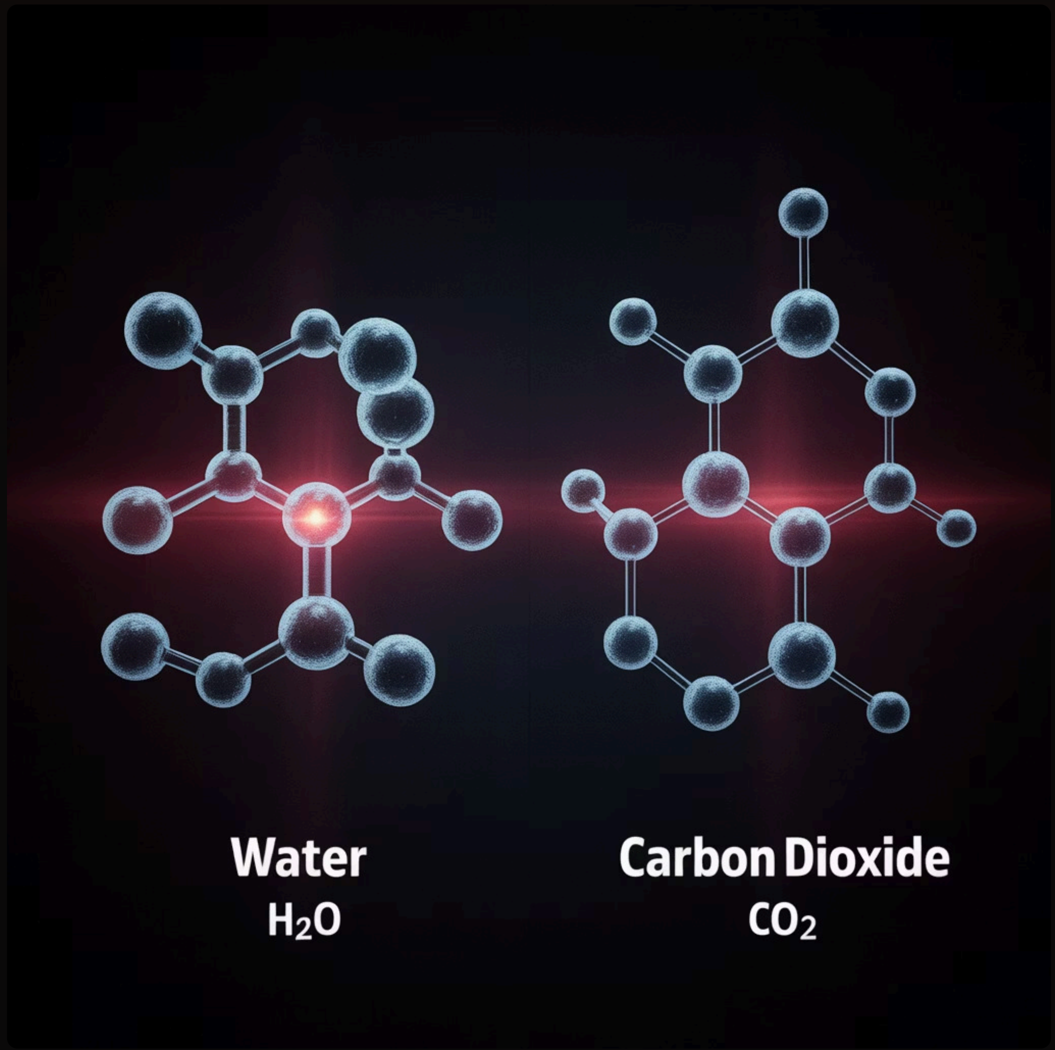
Understanding Polarity

- **Bond Polarity:** Unequal sharing due to electronegativity difference
- **Molecular Polarity:** Overall charge distribution in molecule
- **Polar Molecules:** Uneven charge distribution, have dipole moment
- **Nonpolar Molecules:** Even charge distribution, no dipole moment

Determining Polarity

1. Identify polar bonds
2. Consider molecular geometry
3. Determine if polar bonds cancel out

Examples



- **H_2O:** Polar (bent shape, polar bonds don't cancel)
- **CO_2:** Nonpolar (linear shape, polar bonds cancel)
- **CH_4:** Nonpolar (symmetric, C-H bonds nearly nonpolar)

Intermolecular Forces in Molecular Compounds

London Dispersion Forces

- Present in all molecules
- Stronger in larger molecules with more electrons
- Only force in nonpolar molecules

Dipole-Dipole Forces

- Between polar molecules
- Stronger than London forces
- Alignment of positive and negative ends

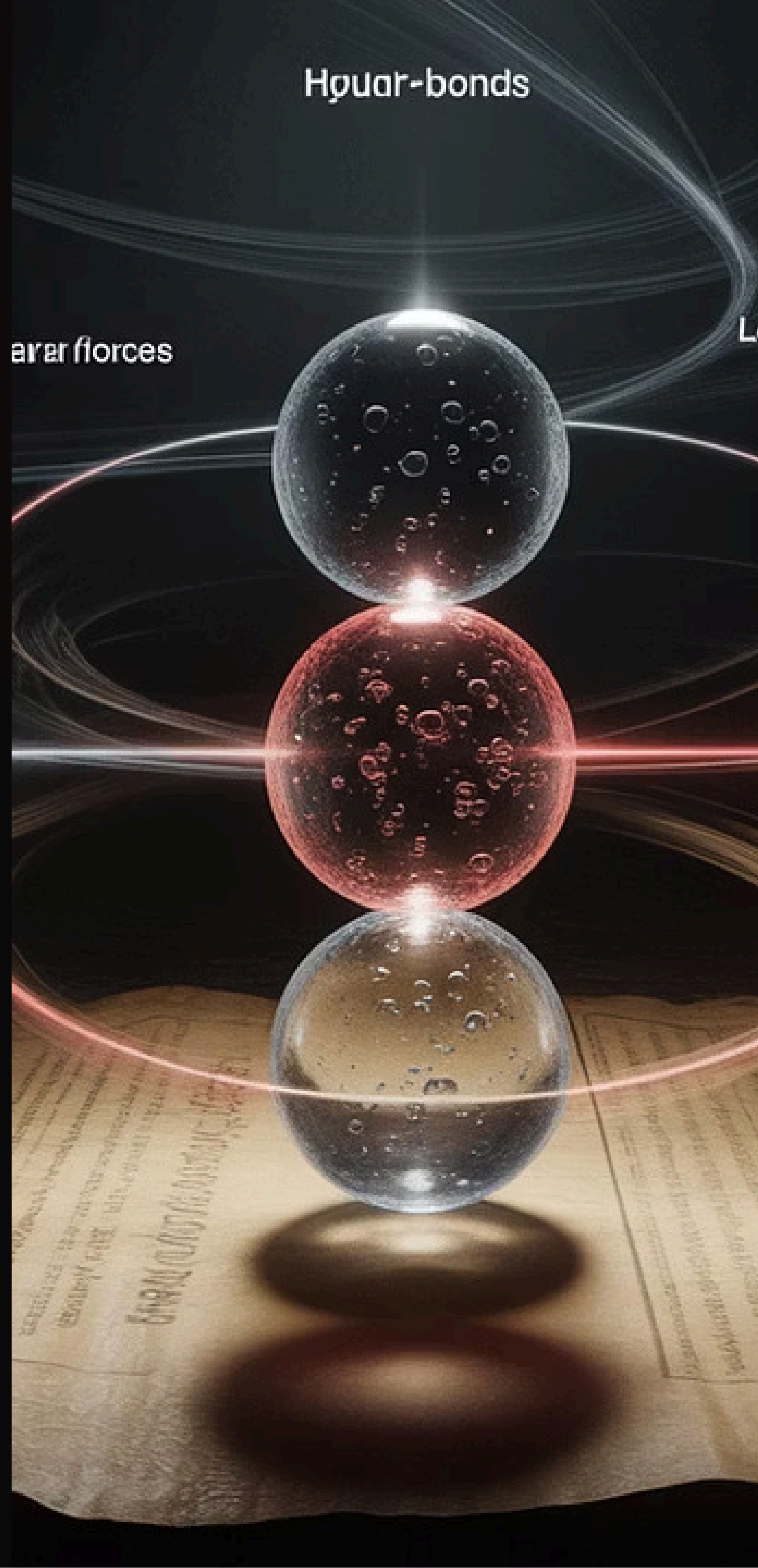
Hydrogen Bonding

- Special case of dipole-dipole
- H attached to N, O, or F
- Strongest intermolecular force

Effect on Properties

Boiling points increase with stronger intermolecular forces: H_2O > HF > HCl > HBr > HI

Solubility follows "like dissolves like" principle: polar dissolves polar, nonpolar dissolves nonpolar



Physical Properties of Molecular Compounds

Melting/Boiling Points

- Generally lower than ionic compounds
- Depend on intermolecular forces
- Example: H_2O (100°C) vs NaCl (801°C)

Solubility

- "Like dissolves like" principle
- Polar compounds dissolve in polar solvents
- Nonpolar compounds dissolve in nonpolar solvents

Electrical Conductivity

- Pure molecular compounds don't conduct
- Some ionize in solution (HCl in water)

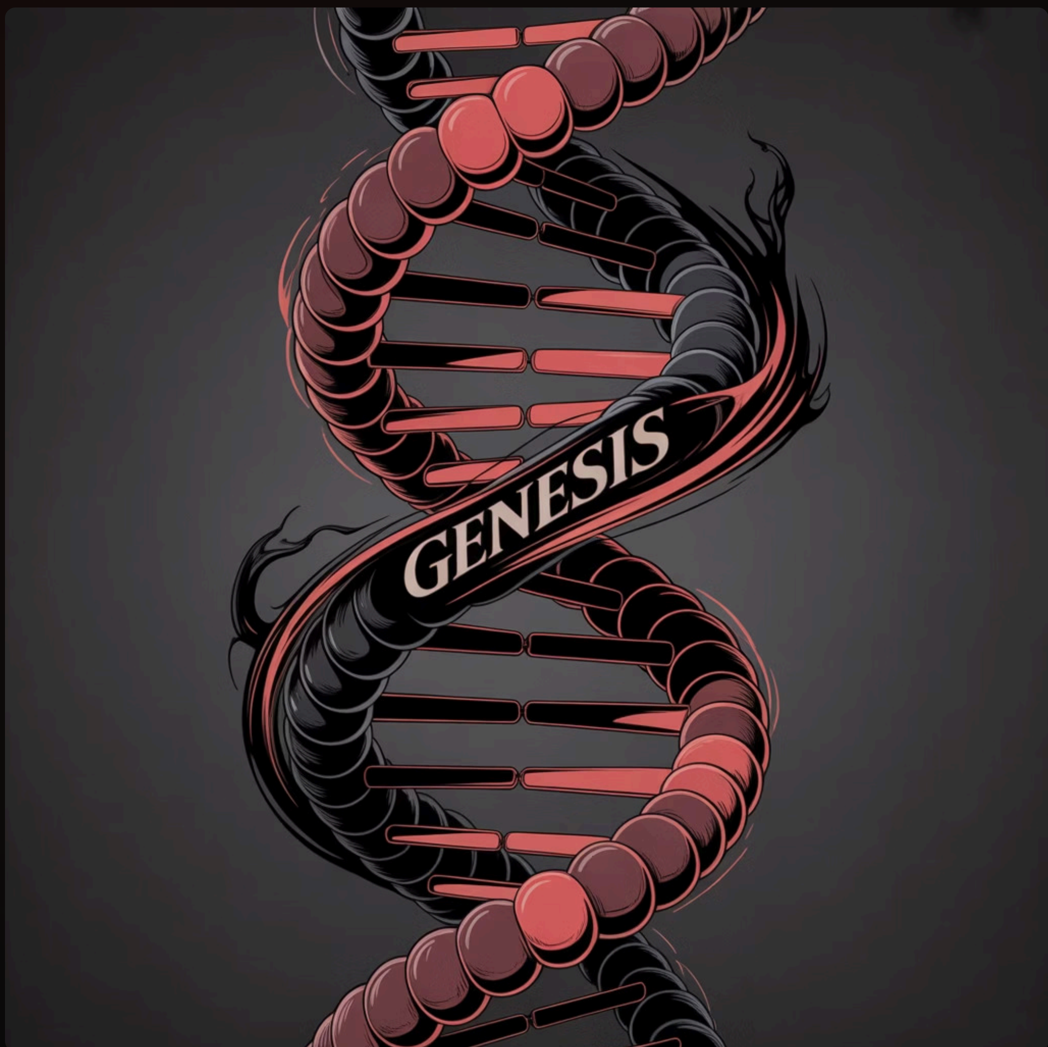
Mechanical Properties

- Often soft or brittle when solid
- Many are gases or liquids at room temperature

Applications and Examples in Daily Life

Biological Molecules

- Proteins: Complex molecular structures
- DNA: Molecular information storage
- Carbohydrates: Energy storage molecules



Environmental Impact

- CO_2: Greenhouse gas affecting climate
- CFCs: Ozone-depleting molecules
- Organic pollutants in environment

Household Items

- Soap: Molecular compounds with polar and nonpolar parts
- Plastics: Long-chain molecular polymers
- Medications: Precisely designed molecular structures

Industrial Applications

- Solvents: Molecular compounds for cleaning/extraction
- Fuels: Hydrocarbon molecular compounds

Coming Up Next: Ions and Ionic Compounds

Mohamed Kamal