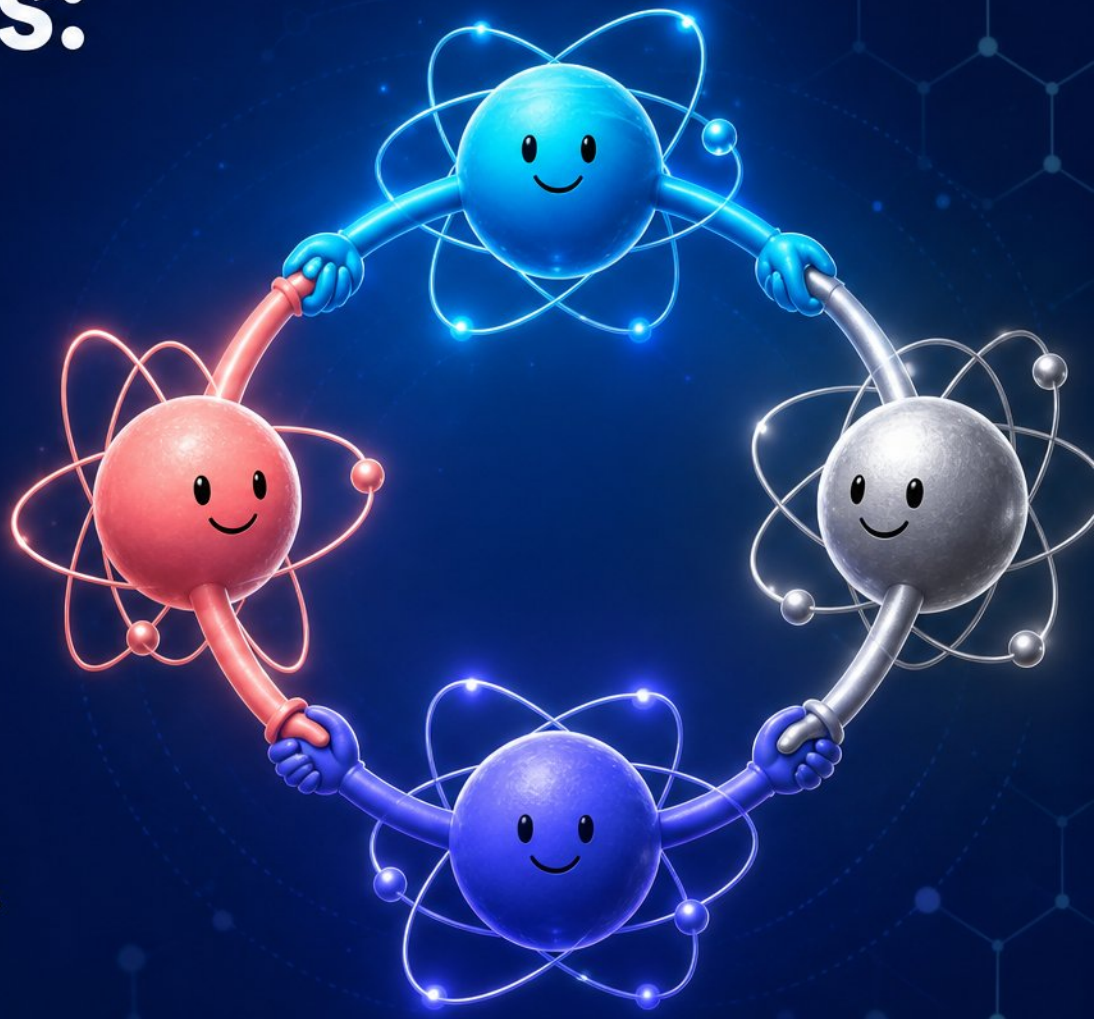
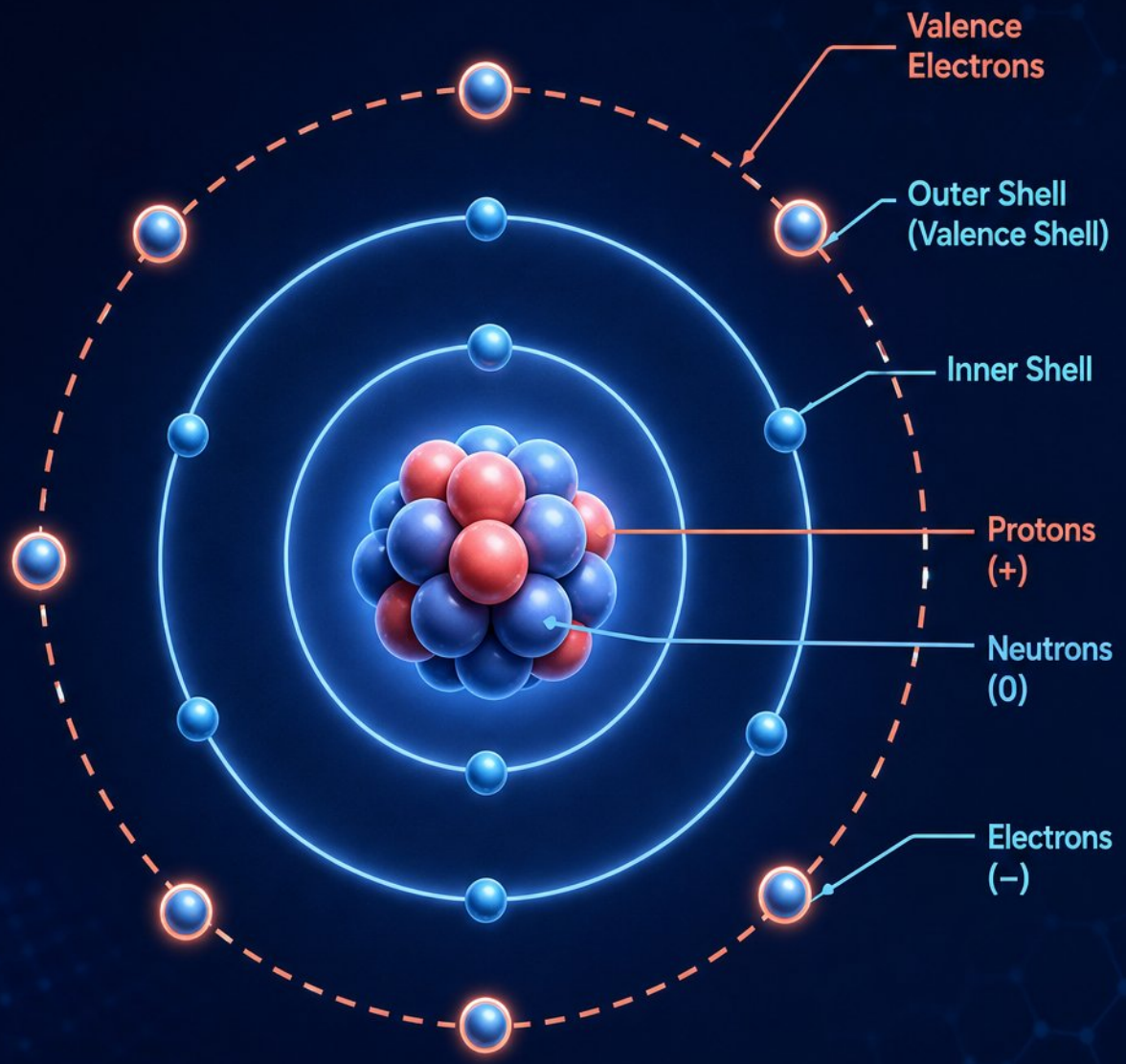
Chemical Bonds: Atoms Joining and Sharing

- Distinguish ionic, covalent, and metallic bonds
- Understand why atoms bond: octet rule stability
- Preview: ionic, covalent, metallic bond roles
- See how bonds form molecules and compounds



Atomic Foundations for Bonding

- Protons, neutrons, and electrons form the basic atomic structure
- Valence electrons in the outermost shell govern reactivity
- The octet rule drives atoms to gain, lose, or share electrons
- Common exceptions: H, He, Be, B, and expanded-octet elements



Atoms, Molecules, and Compounds

ATOM
Single particle

Ne

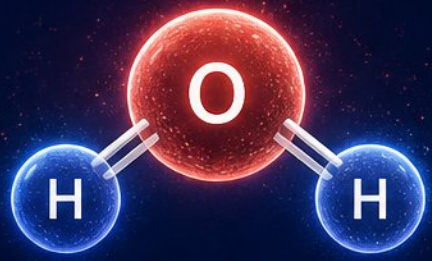
:Ne:

MOLECULE
Bonded atoms of the same element

O_2

O=O

COMPOUND
Bonded atoms of different elements

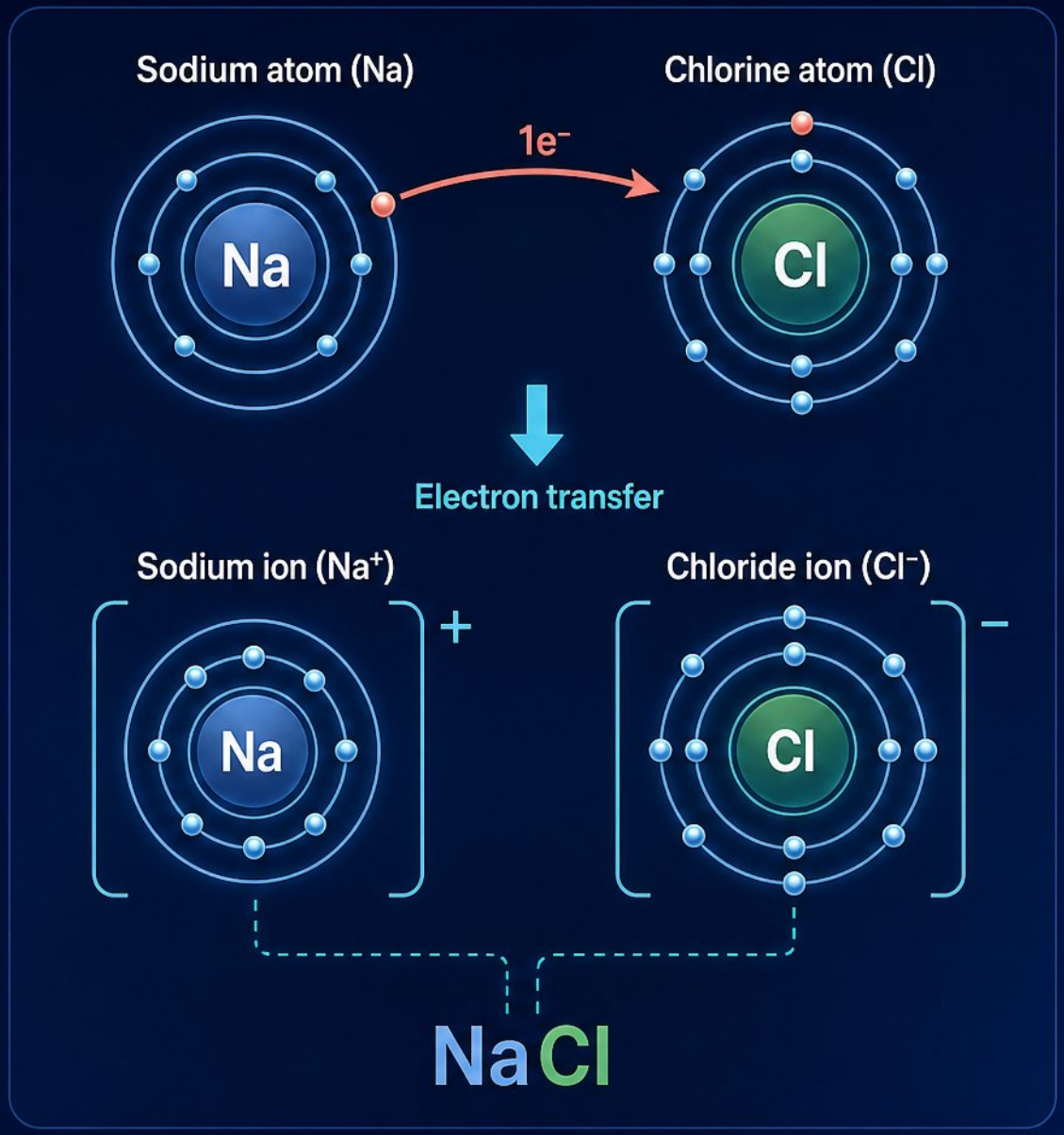


H_2O

H–O–H

- **Atom:** single neutral particle (e.g., Ne)
- **Molecule:** bonded atoms of the same element (e.g., O_2)
- **Compound:** bonded atoms of different elements (e.g., H_2O)
- **Bonding transforms properties:** reactive Na metal vs. stable NaCl salt
- **Represent substances** with chemical formulas and structural formulas

Ionic Bonds: Electron Transfer



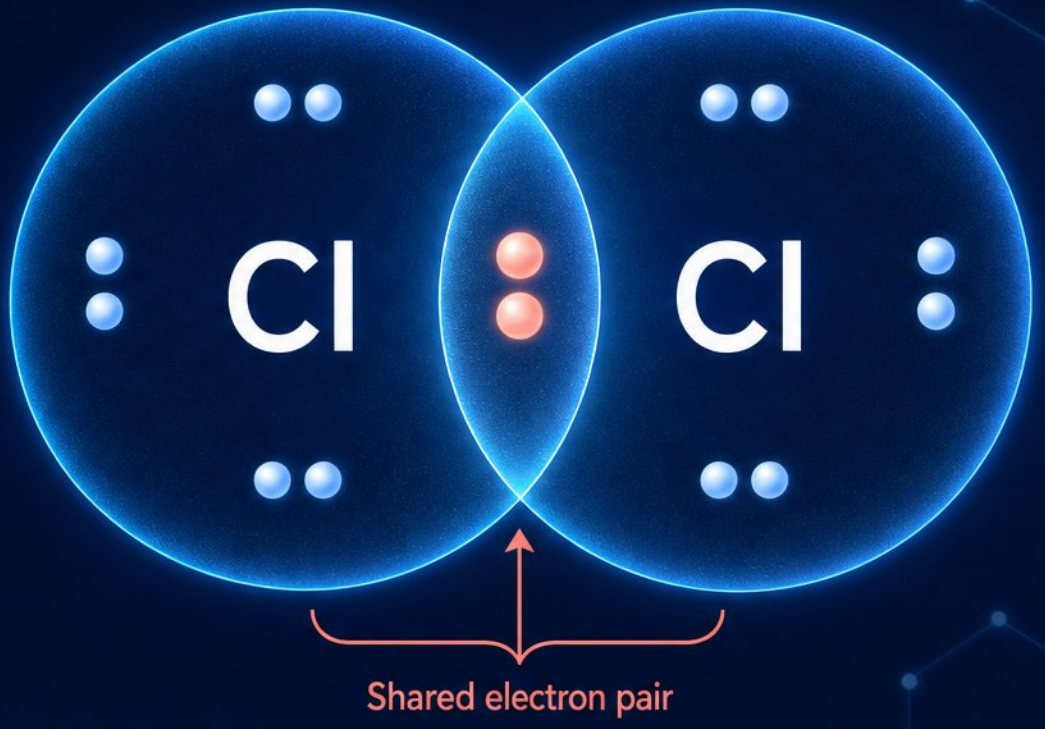
- Metals lose electrons to form cations; nonmetals gain electrons to form anions
- Electrostatic attraction between oppositely charged ions creates the ionic bond
- NaCl formation: Na loses $1e^-$ → Na^+; Cl gains $1e^-$ → Cl^-
- Low ionization energy in metals favors electron loss; high electron affinity in nonmetals favors electron gain
- Resulting ions achieve stable noble gas electron configurations

Ionic Compounds:
Structure and Properties

- Ions form a rigid 3D crystal lattice, not discrete molecules.
- Strong ionic bonds cause high melting points and brittleness.
- Many dissolve in water; conduct electricity only when molten or dissolved.
- Everyday ionic compounds include table salt, baking soda, Epsom salt, and toothpaste fluoride.

Covalent Bonds: Sharing Electrons

- Nonmetal atoms share electrons to reach a full outer shell
- Single bond: one shared pair (e.g., Cl_2)
- Double bond: two shared pairs (e.g., O_2)
- Triple bond: three shared pairs (e.g., N_2)
- Lewis dot structures show shared and lone electron pairs



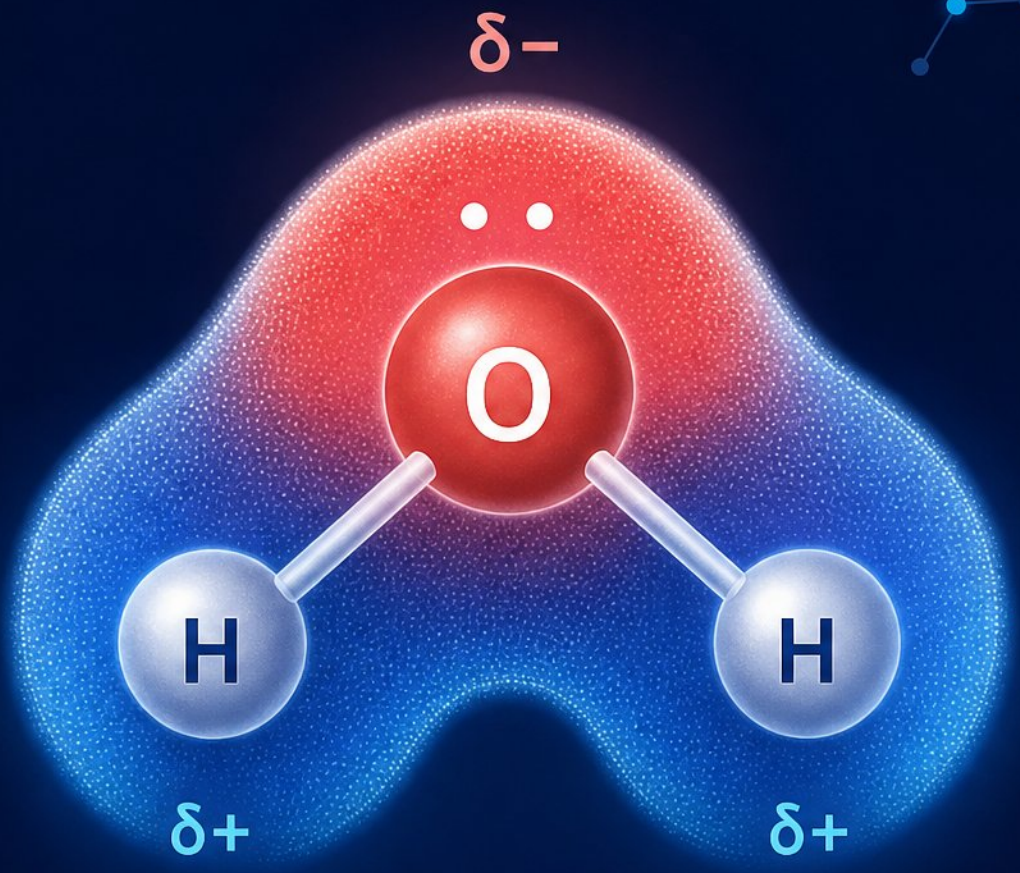
Single bond: one shared pair (e.g., Cl_2)

Double bond: two shared pairs (e.g., O_2)

Triple bond: three shared pairs (e.g., N_2)

Electronegativity and Bond Polarity

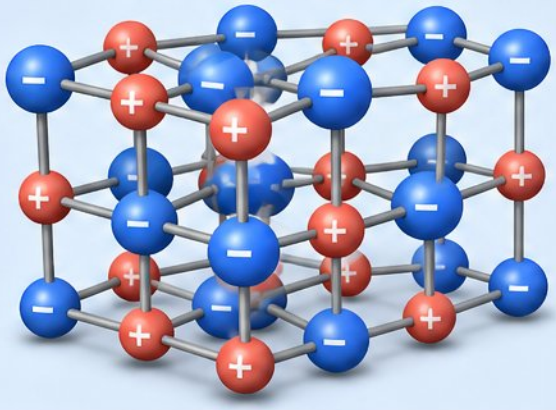
- **Electronegativity:** atom's ability to attract shared electrons (Pauling scale 0.7–4.0)
- **Periodic trend:** increases across a period, decreases down a group; F (3.98) is highest
- **Nonpolar covalent:** equal or near-equal sharing ($\Delta EN \approx 0$; e.g., H_2, CH_4)
- **Polar covalent:** unequal sharing causes partial charges ($\Delta EN < 1.7$; e.g., HCl, H_2O)
- Electron transfer dominates when **$\Delta EN > 1.7$** (ionic); intermediate differences give polar bonds



Comparing Ionic and Covalent Bonds

IONIC BOND

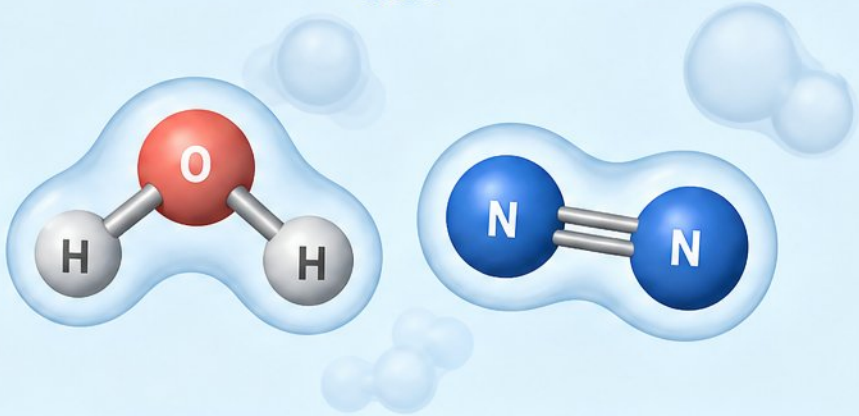
Electrostatic attraction between oppositely charged ions



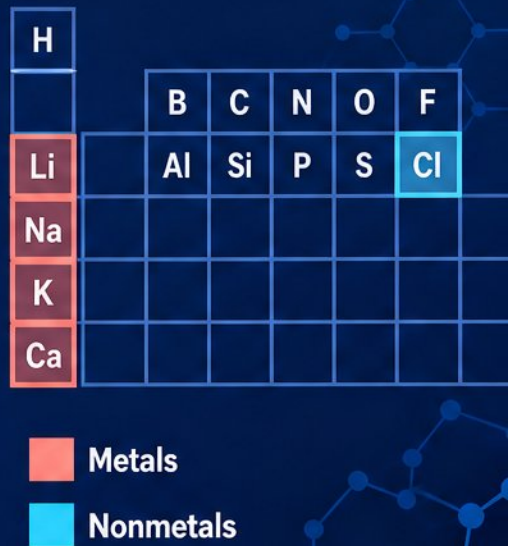
VS

COVALENT BOND

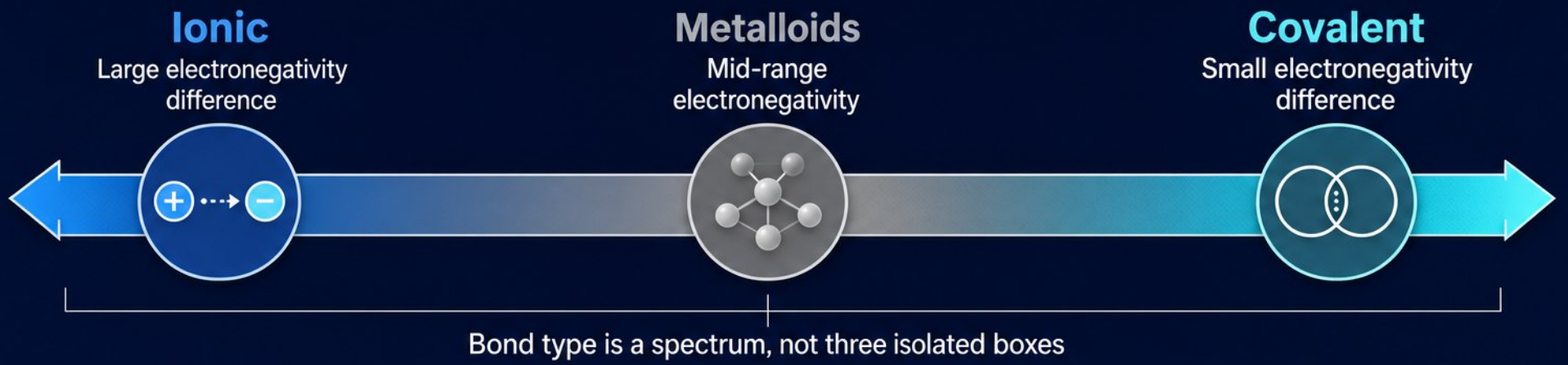
Sharing of electron pairs between atoms



- Electrons are transferred in ionic bonds; shared in covalent bonds.
- Ionic compounds form crystal lattices; covalent substances form discrete molecules.
- Melting points: ionic high, covalent generally lower.
- Conductivity: ionic only when molten/dissolved; covalent typically none.
- Metal + nonmetal → ionic bond; Nonmetal + nonmetal → covalent bond.
- Electronegativity difference >1.7 suggests ionic; <1.7 polar covalent; near zero nonpolar covalent.



Edge Cases and Metalloid Behavior



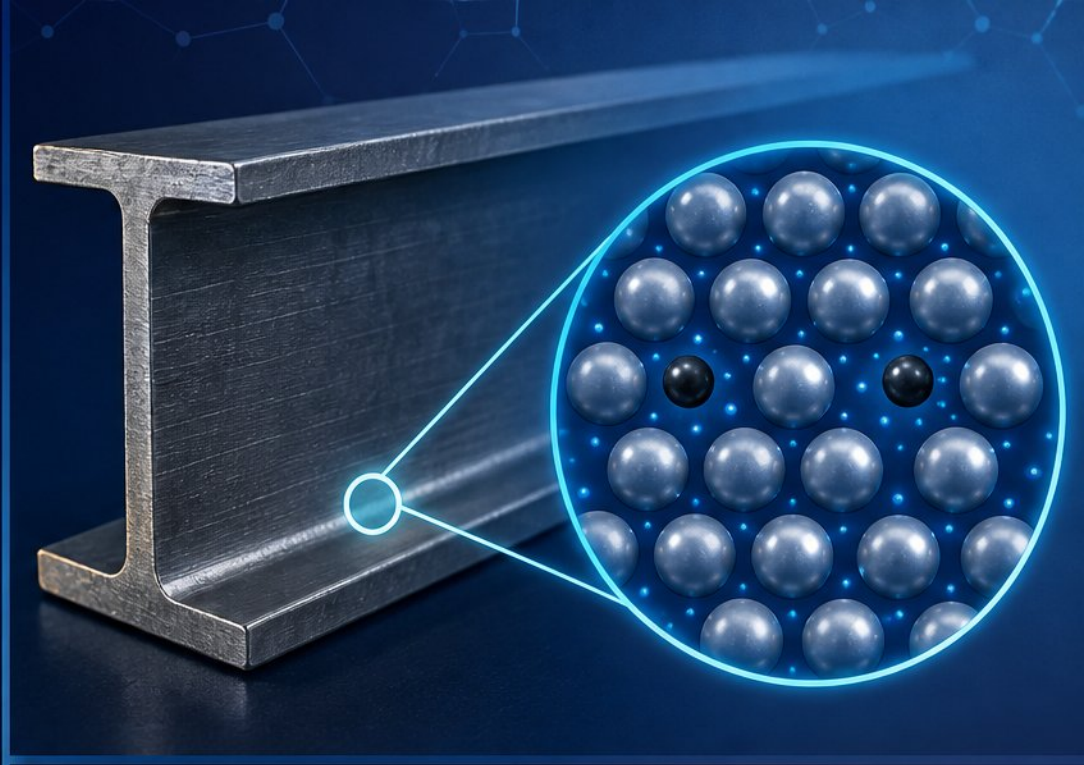
- Rigid bond labels fail with metalloids and mid-range electronegativity
- Intermediate differences create mixed ionic-covalent character
- Bond type is a spectrum, not three isolated boxes
- Example: aluminum chloride ($AlCl_3$) shows both ionic and covalent traits
- Misconception alert: not every crystal structure signals ionic bonding

Metallic Bonds: The Electron Sea

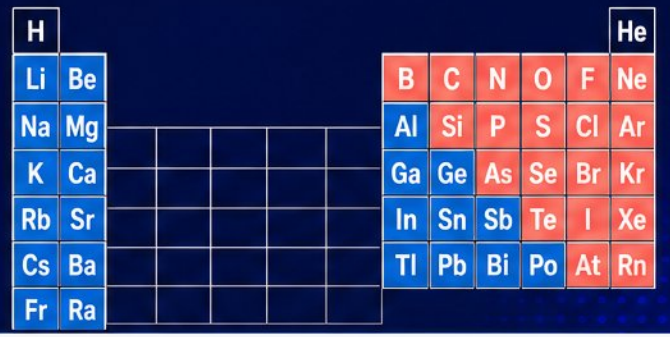
- Cations fixed in a "sea" of delocalized electrons
- Delocalized electrons move freely among metal ions
- Conducts electricity and heat in solid state
- Malleable and ductile—layers slide without breaking
- Lustrous surface reflects light due to electron mobility

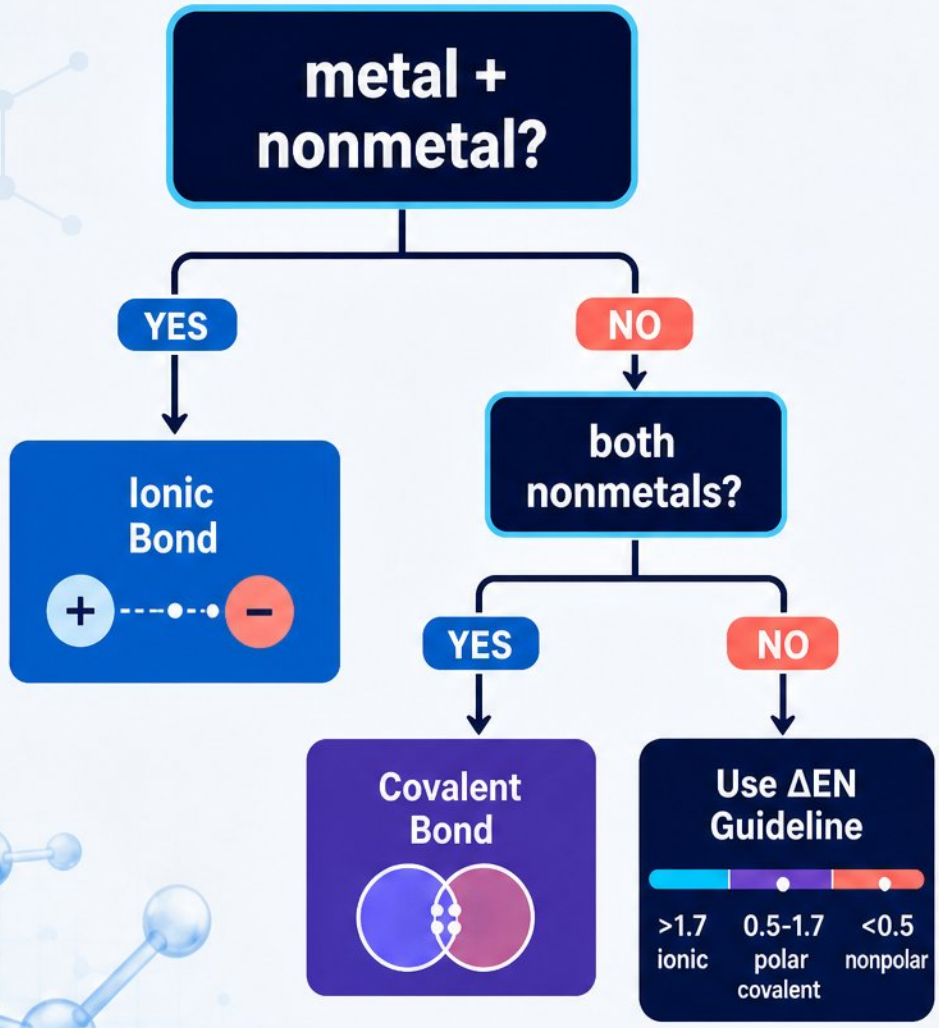
Metallic Bonding in Everyday Alloys

- Alloys: mixtures of metals that enhance material properties
- Steel (iron-carbon): interstitial carbon atoms hinder slip
- Brass (copper-zinc): substitutional atoms resist deformation
- Alloys are often harder, stronger, and more corrosion-resistant
- The electron sea accommodates added or displaced atoms



Classifying Bond Types: A Decision Framework





Step 1:
Identify elements as metals, nonmetals, or both

Step 2:
If metal + nonmetal → likely ionic bond

Step 3:
If nonmetal + nonmetal → likely covalent bond

Step 4:
Calculate ΔEN: >1.7 ionic; 0.5-1.7 polar covalent; <0.5 nonpolar

Practice: Identifying Bonds in Common Substances

- Classify substances as ionic, polar covalent, nonpolar covalent, or metallic
- Confirm bond type using melting point, conductivity, and solubility data
- Work through common examples: NaCl, H_2O, O_2, Fe, brass
- Discuss edge cases and correct frequent classification misconceptions
- Practice predicting properties directly from bond type

Mystery Substances: Classify the Bond Type

Substance A

- Melting Point
- Conductivity (as solid / as liquid)
- Solubility (in water)

Substance B

- Melting Point
- Conductivity (as solid / as liquid)
- Solubility (in water)

Substance C

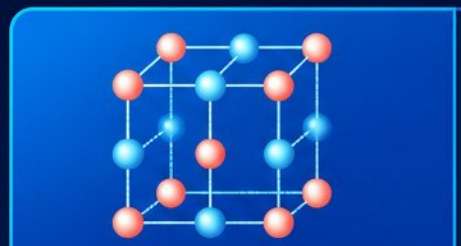
- Melting Point
- Conductivity (as solid / as liquid)
- Solubility (in water)

Substance D

- Melting Point
- Conductivity (as solid / as liquid)
- Solubility (in water)

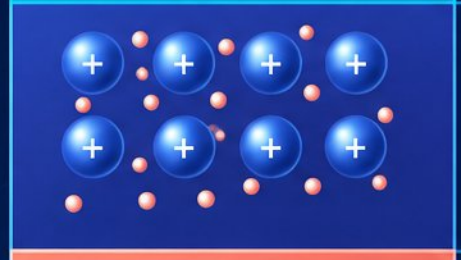
Use the data above to determine the bond type for each substance and justify your reasoning.

Summary: Bond Types at a Glance



- Ionic: electron transfer forms crystal lattices; high melting points, conductive when dissolved

- Covalent: electron sharing forms discrete molecules; lower melting points, varied solubility



- Metallic: sea of delocalized electrons; malleable, lustrous, conductive as solids

- Use element types and electronegativity difference to classify bonds consistently

Knowledge Check and Next Steps

- Multiple-choice quiz: classify substances by bond type and predict their properties
- Application scenarios linking bond behavior to real-world material performance
- Preview: intermolecular forces are distinct from the chemical bonds covered here

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