

Structures and Physical properties

Polarity of Bonds

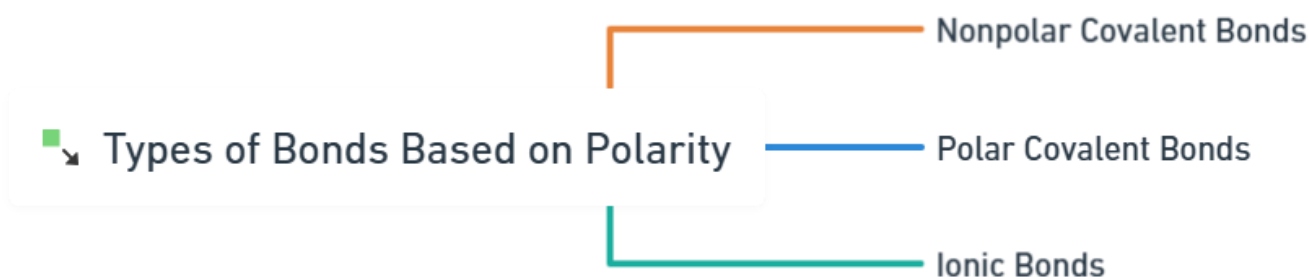
Definition:

- Polarity of a bond refers to the unequal sharing of electrons between two atoms due to a difference in their electronegativities.
- This leads to a partial positive charge on one atom and a partial negative charge on the other, creating a dipole moment.

Electronegativity:

- Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons.
- The most electronegative element is **fluorine** (F = 4.0 on the Pauling scale).
- Common electronegativities (approx.):
 - H: 2.1
 - C: 2.5
 - N: 3.0
 - O: 3.5
 - F: 4.0

Types of Bonds Based on Polarity:



1. Nonpolar Covalent Bonds:

- Electrons are equally shared.
- Occurs when the electronegativity difference (ΔEN) between atoms is less than 0.4.
- Example: H_2 , Cl_2 , CH_4 .

2. Polar Covalent Bonds:

- Electrons are unequally shared.
- ΔEN between 0.4 to 1.7.
- The more electronegative atom pulls the electron pair closer.
- Example: HCl (H is less electronegative than Cl, so the bond is polar).

3. Ionic Bonds:

- Extreme case of polarity where one atom completely loses electron(s) to another.
- ΔEN greater than 1.7.
- Example: NaCl (Na^+ and Cl^-).

Dipole Moment (μ):

- A vector quantity that measures the polarity of a bond.
- $\mu = \delta \times d$
- Where δ is the magnitude of partial charge and d is the bond distance.
- Units: Debye (D); $1 D \approx 3.336 \times 10^{-30} C \cdot m$.
- The larger the dipole moment, the more polar the bond is.

Significance

- **Bond polarity affects:**
 - Solubility (like dissolves like)
 - Reactivity (site of nucleophilic or electrophilic attack)
 - Intermolecular forces
 - Physical properties (melting point, boiling point)

Polarity of Molecules

Definition

- Molecular polarity refers to the overall distribution of electron density across a molecule, determining whether a molecule is polar or nonpolar.

Conditions for Molecular Polarity:

- The molecule is polar if it has:
 - One or more polar bonds, and
 - The dipoles do not cancel each other out due to symmetry.

Factors Affecting Molecular Polarity

1. Bond polarity

- A molecule must contain polar bonds to be polar.
- However, presence of polar bonds alone is not enough; vector addition of dipoles matters.

2. Molecular Geometry

- Shape determines whether dipole moments cancel out or add up.
- Use Valence Shell Electron Pair Repulsion (VSEPR) theory to predict geometry.

Nonpolar Molecules

- Symmetrical arrangement of identical polar bonds.
- Net dipole moment is zero.
- **Examples:**
 - CO_2 (linear): $\text{O}=\text{C}=\text{O} \rightarrow$ dipoles cancel
 - CCl_4 (tetrahedral): Cl atoms symmetrically placed

Polar Molecules

- Asymmetrical shape or different atoms with different electronegativities.
- Net dipole moment is non-zero.
- **Examples:**
 - H_2O (bent): net dipole toward oxygen
 - NH_3 (trigonal pyramidal): dipole toward nitrogen

Importance of Molecular Polarity

- Determines solubility in polar/nonpolar solvents.
- Affects boiling/melting points.
- Influences reaction mechanisms, especially in organic and biochemical reactions.

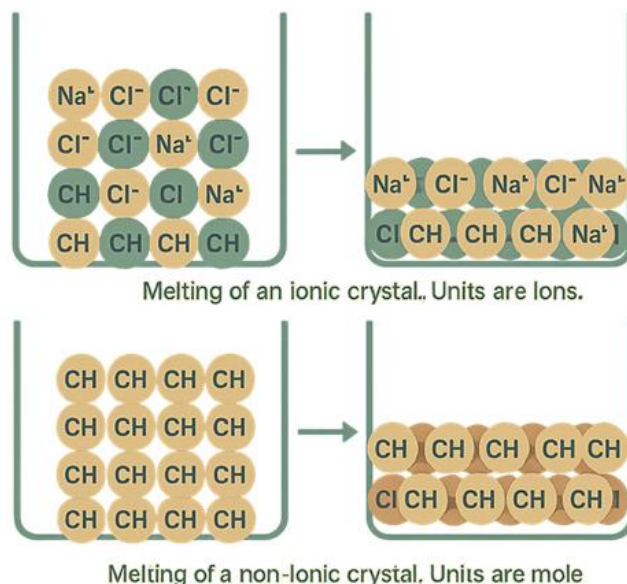
Examples

Molecule	Bond Polarity	Geometry	Molecular Polarity
H_2O	Polar (O–H)	Bent	Polar
CO_2	Polar (C=O)	Linear	Nonpolar
CH_4	Nonpolar (C–H)	Tetrahedral	Nonpolar
NH_3	Polar (N–H)	Trigonal pyramidal	Polar

Melting Point (M.P)

Definition:

- The melting point is the temperature at which a substance changes from solid to liquid at atmospheric pressure.
- It represents the point where the solid and liquid phases are in equilibrium.



Physical Meaning:

- At the melting point, particles in the solid gain enough kinetic energy to overcome the intermolecular forces holding them in fixed positions.
- They then move more freely and the substance transitions into a liquid state.

Melting Point and Purity:

- Pure substances have a sharp melting point — they melt at a specific temperature.
- Impure substances have:
 - Lower melting point
 - Broader melting range
- This property is often used in laboratories to determine the purity of compounds.

Units

- Typically measured in degrees Celsius (°C) or Kelvin (K).

Types of Substances and Their Melting Points

A. Ionic Compounds

- Have high melting points.
- Strong electrostatic forces between cations and anions require high energy to break.
- Example: NaCl (801°C)

B. Covalent Molecular Compounds

- Have lower melting points.
- Held together by weak van der Waals forces, dipole-dipole, or hydrogen bonds.
- Example: Ice (H₂O): 0°C

C. Metallic Compounds

- Moderate to high melting points.
- Sea of delocalized electrons provides strong bonding.
- Example: Fe (1538°C)

D. Network Covalent Compounds

- Extremely high melting points.
- Atoms bonded by covalent bonds throughout the structure.
- Example: Diamond ($\approx 3550^\circ\text{C}$)

Factors Affecting Melting Point:

1. Intermolecular Forces:

- Stronger forces = Higher melting point.
- Types of forces:
 - Ionic > Hydrogen bonding > Dipole-dipole > Van der Waals

2. Molecular Size and Mass:

- Larger molecules often have higher melting points due to more electrons and thus greater London dispersion forces.

3. Molecular Symmetry and Packing:

- Molecules that pack well in the solid state (high symmetry) tend to have higher melting points.
- Example: naphthalene has a high melting point due to good packing.

4. Polarity:

- Polar compounds generally have higher melting points than nonpolar ones, due to stronger dipole-dipole attractions.

5. Ionic Compounds:

- Have very high melting points due to strong electrostatic attraction between oppositely charged ions.
- Example: NaCl (801°C), MgO (2852°C)

6. Hydrogen Bonding:

- Molecules with H-bonding (e.g., ice, alcohols) have elevated melting points relative to their molar mass.

Examples:

Compound	Type	M.P. ($^\circ\text{C}$)	Reason
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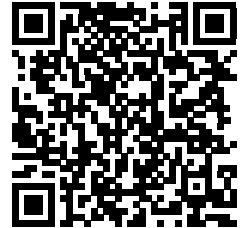


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