Chapter 10

**Molecular Polarity**

- There is a continuum from non-polar to ionic, with no clear breaks. However, we will define some arbitrary cut-off points:
  - **Nonpolar Covalent Bonds** ($\Delta EN \leq 0.4$)
    - (electrons unevenly shared)
  - **Polar Covalent Bonds** ($0.5 \leq \Delta EN \leq 1.6$)
    - (electrons unevenly shared)
  - **Ionic Bonds** ($\Delta EN \geq 1.7$)
    - (full charges)

**Bond Polarity**

- In reality, few bonds are completely ionic or completely covalent.
- The **electronegativity difference ($\Delta EN$)** between two atoms will allow us to determine whether two atoms in a bond will display more ionic properties or more covalent properties.

**Ionic and Covalent Bonds**

- An **ionic bond** is a bond in which a cation and an anion have an electrostatic attraction for one another.
- A **covalent bond** is a bond in which two atoms share electrons. It is the mutual attraction of two nuclei for the same electrons that keeps the atoms together.

**Bond Polarity**

- If the electrons are *shared evenly*, the bond is **non-polar**.
- If the electrons are *shared unevenly*, the bond is considered **polar** — it has a positive side and a negative side.
- If one atom has an attraction so much stronger than the other atom that it pulls the electrons away, then we consider the bond to be **ionic**.

**Chart of Electronegativities**

- The chart shows the electronegativity values for various elements, with a range from 0.1 to 5.
- Elements with similar electronegativity values are grouped together.

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Molecular Polarity

- Bonds are considered polar or non-polar based on electronegativity differences.
- A molecule will only be a dipole (polar) when 2 criteria are met:
  1. There is a polar bond in the molecule.
  2. There is asymmetry with respect to charge.

Methane (CH₄)

- Are the bonds polar?
  \( \Delta EN = 2.5 - 2.1 = 0.4 \) \( \rightarrow \) NO

- Therefore, methane is a NON-POLAR Molecule.

- We do NOT need to ask the second question: *Is there any charge asymmetry in the molecule?*

Ammonia (NH₃)

- Are the bonds polar?
  \( \Delta EN = 3.0 - 2.1 = 0.9 \) \( \rightarrow \) YES, polar bonds:
  \( \delta^- \text{N} \delta^+ \text{H} \)

- Is there any charge asymmetry?
  Consider the shape: Trigonal pyramidal \( \rightarrow \) YES

- Therefore, Ammonia is a POLAR Molecule.

Water (H₂O)

- Are the bonds polar?
  \( \Delta EN = 3.5 - 2.1 = 1.4 \) \( \rightarrow \) YES, polar bonds:
  \( \delta^- \text{O} \delta^+ \text{H} \)

- Is there any charge asymmetry?
  Consider the shape: Bent (~105°) \( \rightarrow \) YES

- Therefore, Water is a POLAR Molecule.

Carbon Dioxide (CO₂)

- Are the bonds polar?
  \( \Delta EN = 3.5 - 2.5 = 1.0 \) \( \rightarrow \) YES, polar bonds:
  \( \delta^+ \text{C} \delta^- \text{O} \)

- Is there any charge asymmetry?
  Consider the shape: Linear \( \rightarrow \) NO

- Therefore, carbon dioxide is a NON-POLAR Molecule.

Boron Trifluoride (BF₃)

- Are the bonds polar?
  \( \Delta EN = 4.0 - 2.0 = 2.0 \) \( \rightarrow \) YES, polar bonds:
  (despite large \( \Delta EN \), bonds have covalent character)
  \( \delta^+ \text{B} \delta^- \text{F} \)

- Is there any charge asymmetry?
  Consider the shape: Trigonal Planar \( \rightarrow \) NO

- Therefore, BF₃ is a NON-POLAR Molecule.
- COCl₂ is a POLAR molecule.

- XeF₄ is a NON-POLAR molecule.

- SF₂ is a POLAR molecule.

- CH₃Cl₂ is a NON-POLAR molecule.

- CH₃CN is a POLAR molecule:

- CH₃CH(OH)CH₃ is a POLAR molecule.