9.5 Electronegativity and Bond Polarity

There is no clear cut between ionic and covalent bonds – pure ionic and pure covalent bonds are only limiting models.

Electronegativity

- **Electronegativity (EN)** – the ability of an atom to attract the shared electrons in a bond (electron-pulling power)
  - In general, EN increases with increasing the ionization energy and electron affinity of atoms
  - EN increases up and to the right in the periodic table (opposite to the atomic size trend)

- EN can be used to determine the oxidation numbers of elements in compounds
  - The more electronegative atom in a bond is assigned all shared (bonding) electrons
  - Each atom in a bond is assigned all unshared (lone pair) electrons
  \[ \text{Ox#} = (\# \text{valence } e^-) - (\# \text{shared } e^- + \# \text{unshared } e^-) \]

**Example: HCl** (Cl is more EN than H)

\[ \text{Cl} \rightarrow \text{Ox#} = 7 - (2 + 6) = -1 \]
\[ \text{H} \rightarrow \text{Ox#} = 1 - (0 + 0) = +1 \]

⇒ H:Cl: or H—Cl: 

Polar Covalent Bonds

- The EN difference (ΔEN) between the bonded atoms determines the character of a covalent bond
  - **Nonpolar covalent bond** – ΔEN = 0 → equal sharing of the bonding electrons (H–H, F–F, ...)
  - **Polar covalent bond** – ΔEN > 0 → unequal sharing of the bonding electrons (H–O, C–F, ...)
    - The more electronegative atoms acquire partial negative charges (have greater share of the bonding electrons)
    - The less electronegative atoms acquire partial positive charges
Formation of a bond dipole expressed by a polar arrow:

- Polar arrow points from \((\delta^+\rangle\) to \((\delta^-)\)
- Bond polarity increases with increasing \(\Delta EN\)

**Example:**

Which of the following bonds is more polar?

- O–H (in H₂O) or N–H in (NH₃)

EN order → H < N < O

⇒ \(\Delta EN(O-H) > \Delta EN(N-H)\)

⇒ the O-H bond is more polar

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### 9.6 Metallic Bonding (see page 382 in textbook)

**The Electron-sea Model**

- A metallic solid can be viewed as an array of metal cations (nuclei + core electrons) attracted by a sea of their valence electrons
  - The valence electrons are delocalized (shared between all atoms)

**Properties of metals**

- **Good electrical and heat conductors** – due to the mobility of the electron-sea
- **Moderately high melting points** – the attractions between the cations and the electron-sea are not greatly disturbed by melting
- **High boiling points** – the metal ions and electrons have to be separated
- **Malleable and ductile** – metal cations can slide past each other without disturbing the interaction with the electron-sea too much