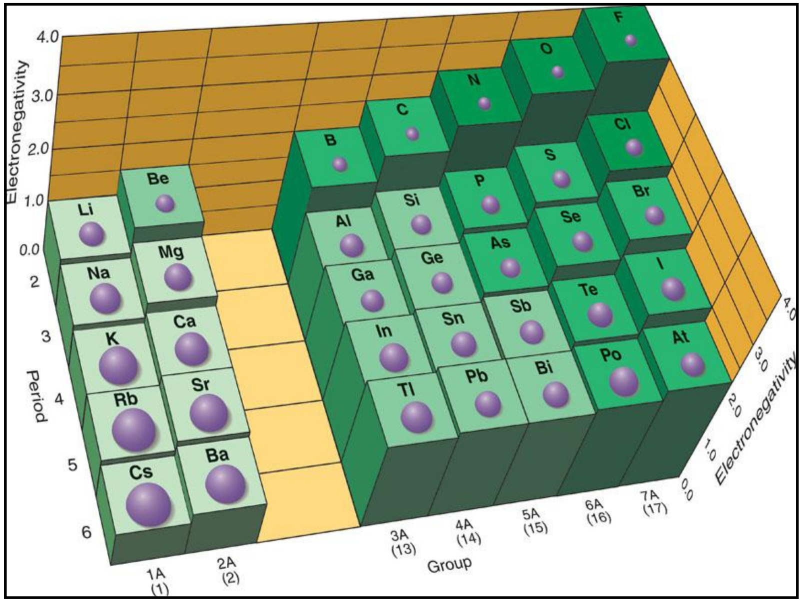
9.5 Electronegativity and Bond Polarity

- 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)



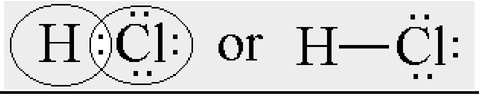
- **EN** can be used to determine the **oxidation numbers** of elements in compounds
  - The more electronegative atom in a bond is assigned all shared (bonding) electrons
  - Each atom in a bond is assigned all unshared (lone pair) electrons

⇒ **Ox#** = (#valence $\mathbf{e^-}$) – (#shared $\mathbf{e^-}$ + #unshared $\mathbf{e^-}$)

Example: HCl (Cl is more EN than H)

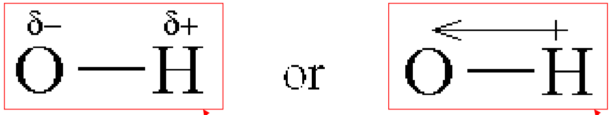
Cl → Ox# = 7 – (2 + 6) = -1

H → Ox# = 1 – (0 + 0) = +1



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 (δ+) to (δ-)

– Bond polarity increases with increasing **ΔEN**

Example:

Which of the following bonds is more polar?
O–H (in H_2O) or **N–H** in (NH_3)

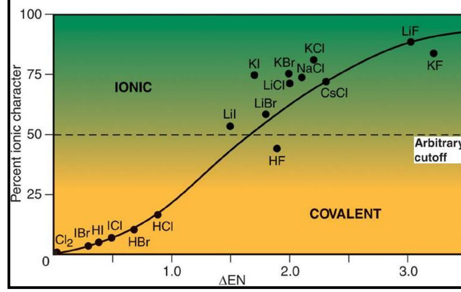
EN order → H < N < O

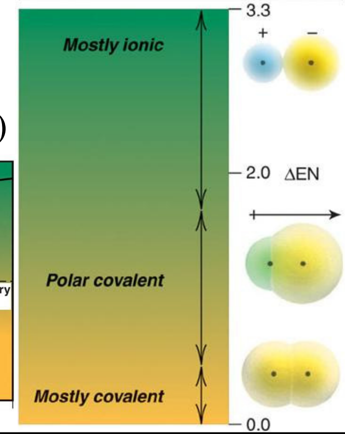
⇒ ΔEN(O-H) > ΔEN(N-H)

⇒ the O-H bond is more polar

- **Partial ionic character** of polar covalent bonds
  - Due to the partial charges
  - Ionic character increases with increasing of **ΔEN**
  - No bonds are 100% ionic (partial covalent character)

ΔEN	IONIC CHARACTER
>1.7	Mostly ionic
0.4-1.7	Polar covalent
<0.4	Mostly covalent
0	Nonpolar covalent





ΔEN=2.1 ΔEN=1.8 ΔEN=1.5 ΔEN=1.2 ΔEN=0.9 ΔEN=0.5 ΔEN=0

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