Week 2
INTERATOMIC BONDING

Materials Science

Atomic Structure

- Valence electrons (electrons at outermost shell) determine all of the following properties
  1) Chemical
  2) Electrical
  3) Thermal
  4) Optical

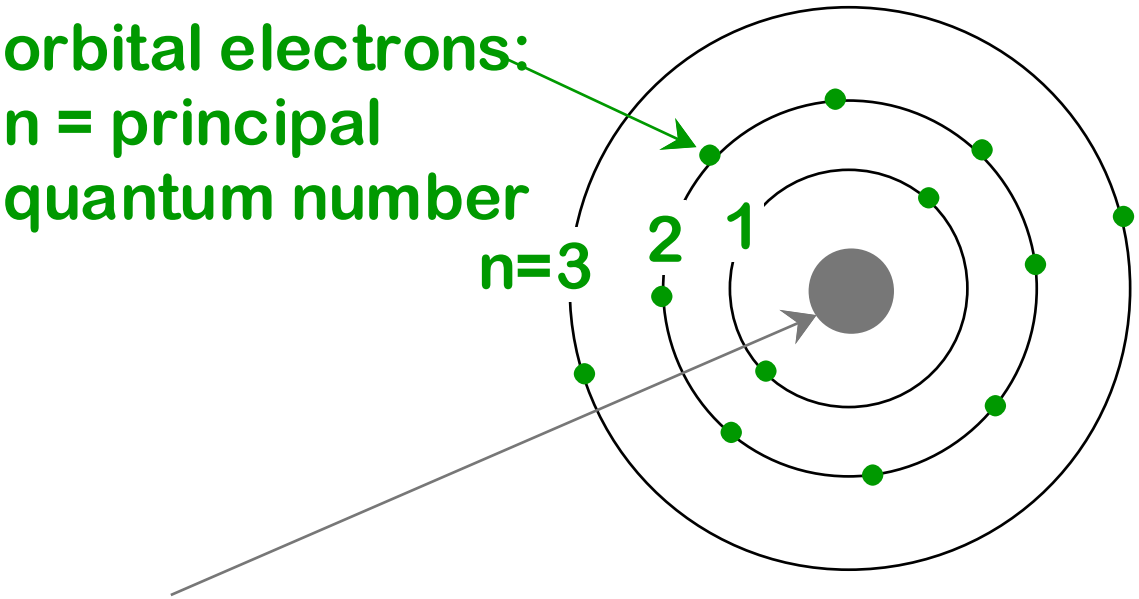
Electronic Structure

- Electrons have wavelike and particulate properties.
- This means that electrons are in orbitals defined by a probability.
- Each orbital at discrete energy level determined by quantum numbers.

Electron Configurations

- Valence electrons – those in unfilled shells.
- Filled shells are more stable.
- Valence electrons are most available for bonding and tend to control the chemical properties .

Electron Configurations



Nucleus: Z = # protons (1 for H to 94 for Pu)

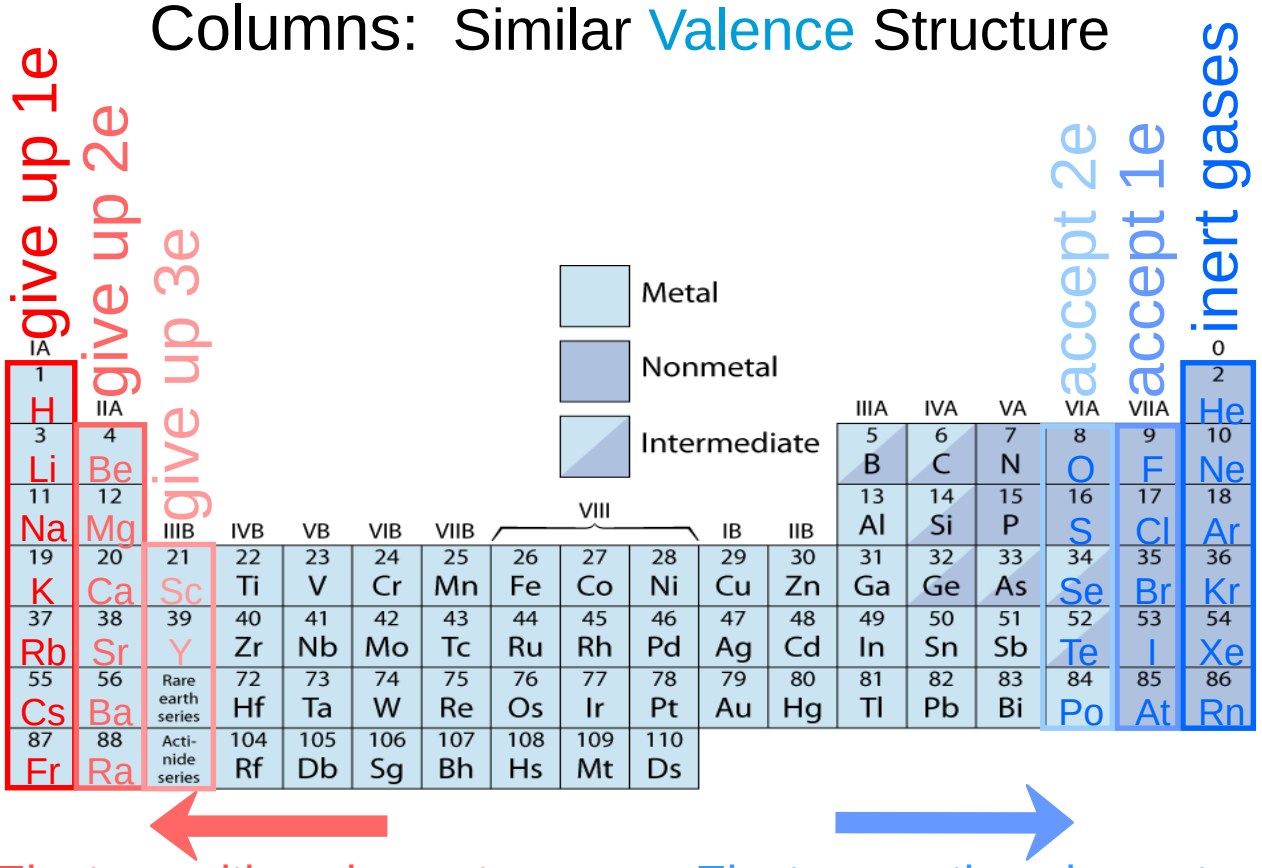
N = # neutrons

Atomic Number = Z

Atomic mass A ≈ Z + N

The Periodic Table

Columns: Similar Valence Structure



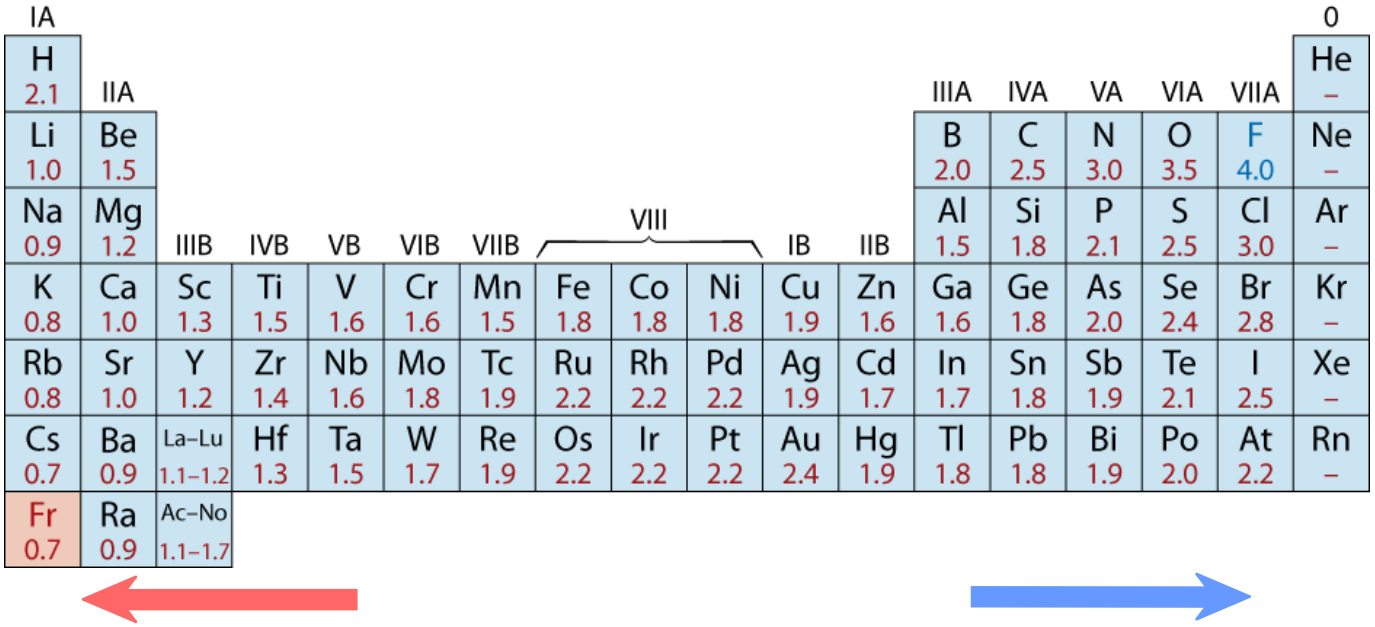
Adapted from Fig. 2.6, *Callister 7e.*

Electropositive elements: Readily give up electrons to become + ions.

Electronegative elements: Readily acquire electrons to become - ions.

Electronegativity

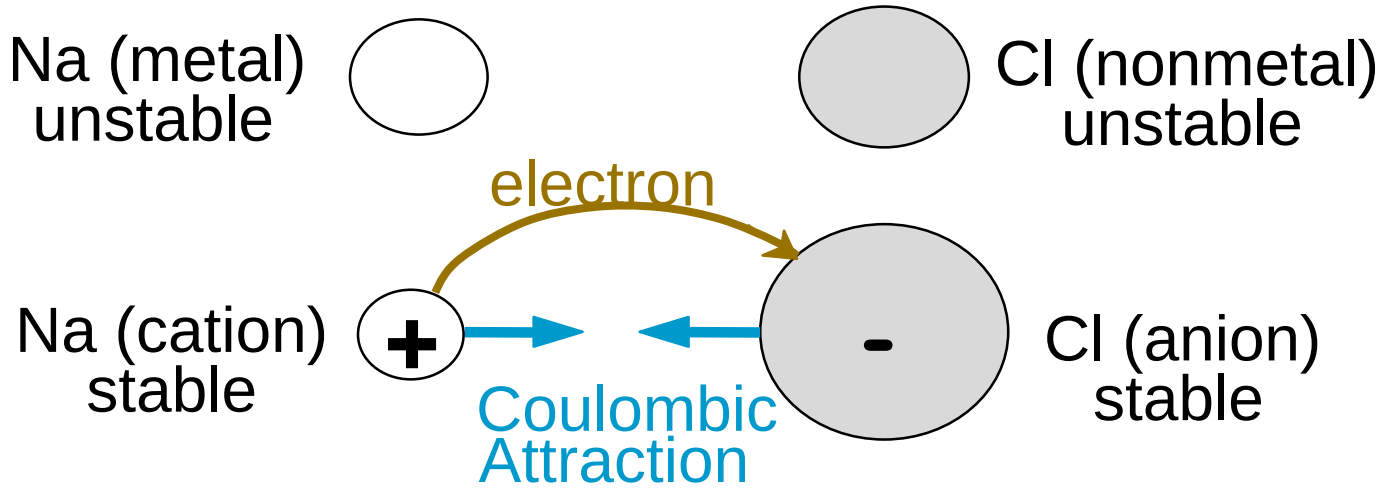
- Ranges from 0.7 to 4.0,
- Large values: tendency to acquire electrons.



Adapted from Fig. 2.7, *Callister 7e.* (Fig. 2.7 is adapted from Linus Pauling, *The Nature of the Chemical Bond*, 3rd edition, Copyright 1939 and 1940, 3rd edition. Copyright 1960 by Cornell University.

Ionic Bonding

- Occurs between + and - ions.
- Requires electron transfer.
- Large difference in electronegativity required.
- Example: NaCl



Ionic Bonding

Ionic bond – metal + nonmetal

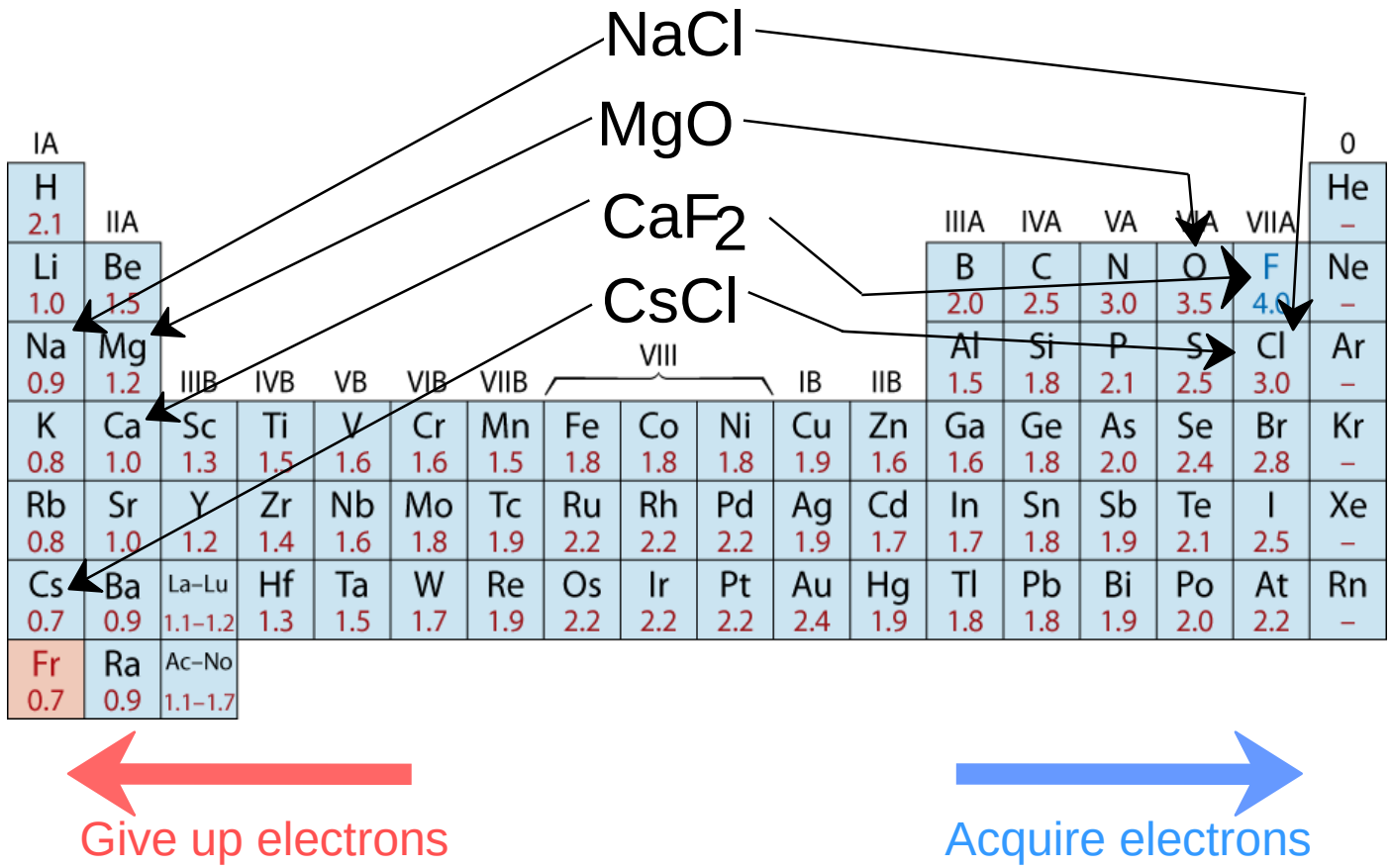
donates electrons

accepts electrons

Dissimilar electronegativities needed.

Examples: Ionic Bonding

- Predominant bonding in Ceramics



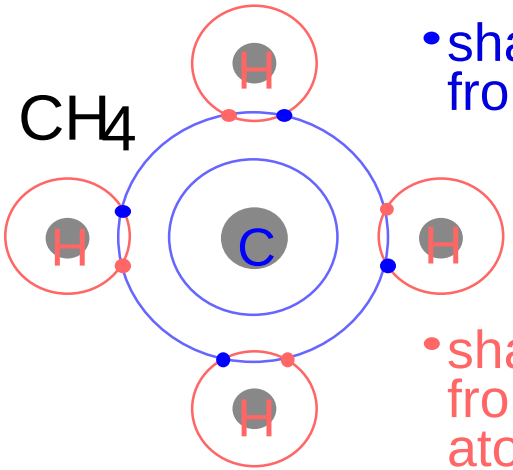
Covalent Bonding

- similar electronegativity ∴ share electrons
- bonds determined by valence – *s* & *p* orbitals dominate bonding
- Example: CH_4

C: has 4 valence e^-, needs 4 more

H: has 1 valence e^-, needs 1 more

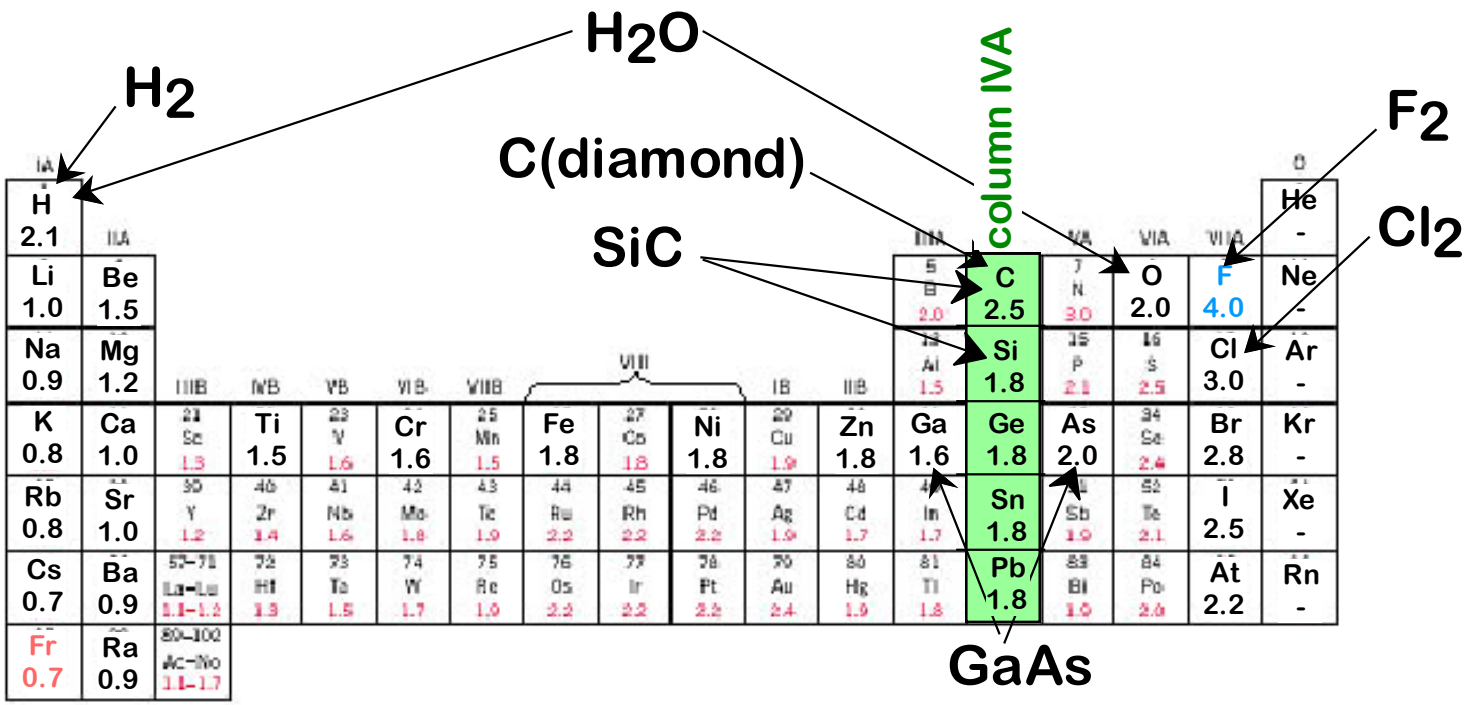
Electronegativities are comparable.



- shared electrons from carbon atom
- shared electrons from hydrogen atoms

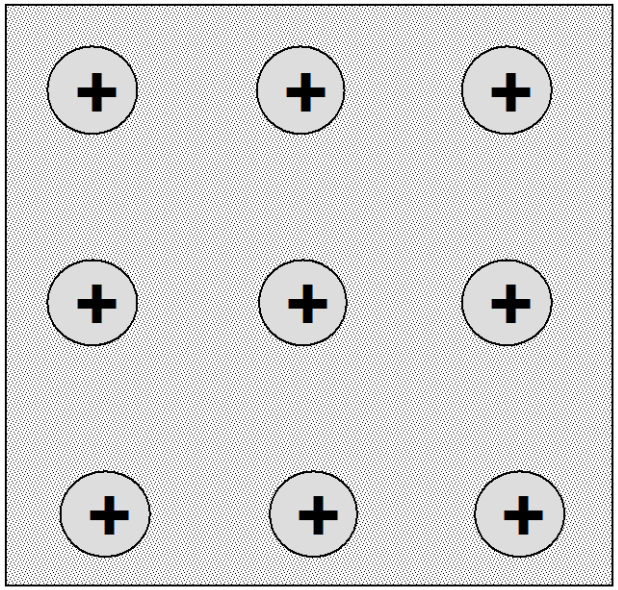
- It is a bond with a localized direction.

Examples: Covalent Bonding



- Molecules with nonmetals
- Molecules with metals and nonmetals
- Elemental solids (RHS of Periodic Table)
- Compound solids (about column IVA)

Metallic Bonding



- Primary bond for metals and their alloys
- It is a strong and nondirectional bonding.

Summary: Bonding

Type	Bond Energy	Comments
Ionic	Large!	Nondirectional (ceramics)
Covalent	Variable large-Diamond small-Bismuth	Directional semiconductors, ceramics polymer chains)
Metallic	Variable large-Tungsten small-Mercury	Nondirectional (metals)

Summary: Primary Bonds

Ceramics

(Ionic & covalent bonding):

Large bond energy

large T_m
large E
small α

Metals

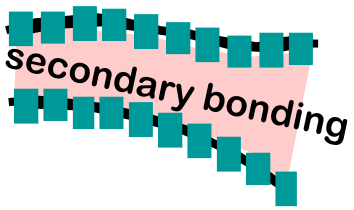
(Metallic bonding):

Variable bond energy

moderate T_m
moderate E
moderate α

Polymers

(Covalent & Secondary):



Directional Properties

Secondary bonding dominates

small T_m
small E
large α