

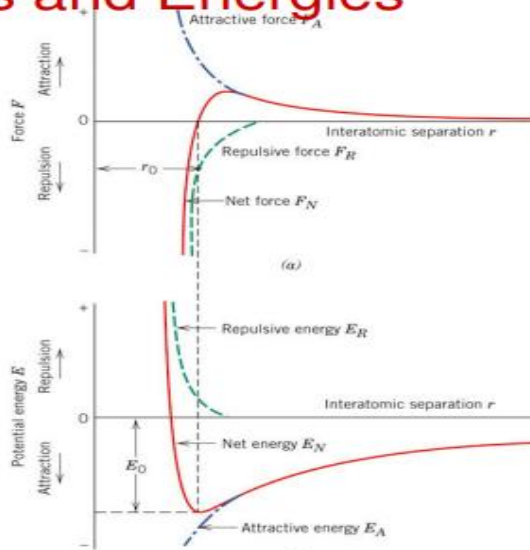
Atomic Structure and Interatomic Bonding

Interatomic Bonding

- Bonding forces and energies
- Primary interatomic bonds
- Secondary bonding
- Molecules

Bonding Forces and Energies

- Considering the interaction between two isolated atoms as they are brought into close proximity from an infinite separation.
- At larger distances, the interactions are negligible.
- As the atoms approach, each exerts forces on the other.
 - Attractive
 - Repulsive
- Ultimately, the outer electron shells of the two atoms begin to overlap, and a strong repulsive force comes into play.

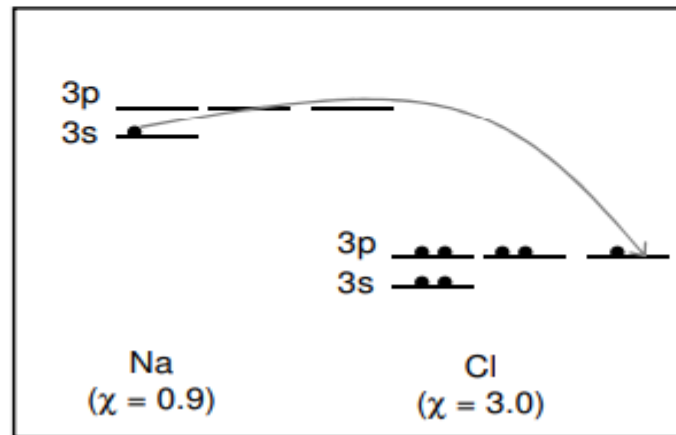
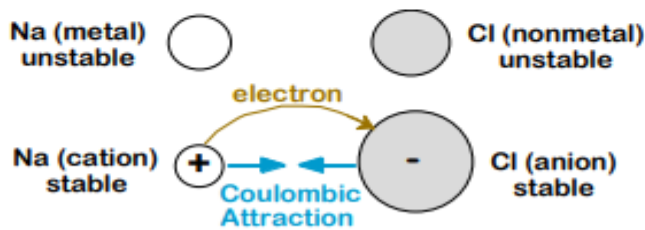


Bonding energy between two atoms

- The interaction energy at equilibrium is called the bonding energy between the two atoms.
- To break the bond, this energy must be supplied from outside.
- Breaking the bond means that the two atoms become infinitely separated.
- In real materials, containing many atoms, bonding is studied by expressing the bonding energy of the entire materials in terms of the separation distances between all atoms, see later discussion.

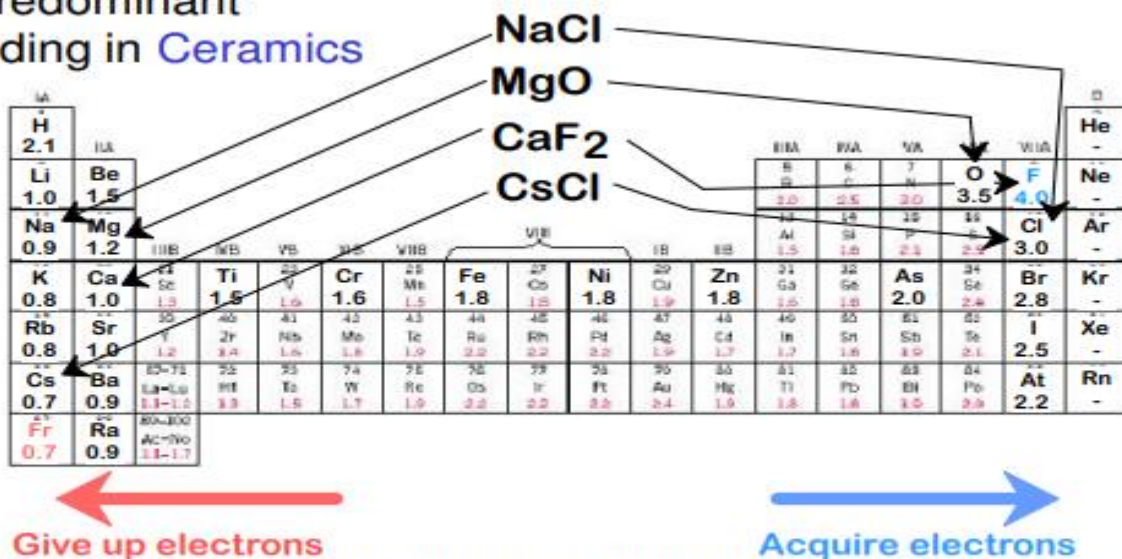
Ionic Bonding

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



examples

- Predominant bonding in **Ceramics**



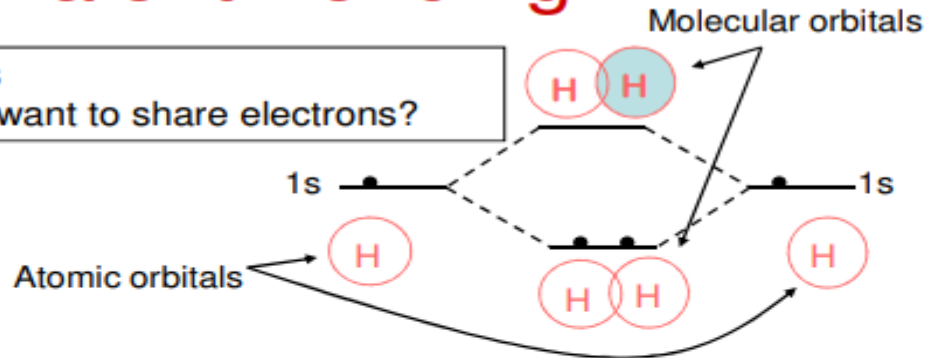
Adapted from Fig. 2.7, Callister 6e. (Fig. 2.7 is adapted from Linus Pauling, *The Nature of the Chemical Bond*, 3rd edition, Copyright 1939 and 1940, 3rd edition. Copyright 1960 by Cornell University.

From Callister 6e resource CD.

Covalent Bonding

- “Sharing” of **electrons**
- Why do some atoms want to share electrons?

- Example1: H_2

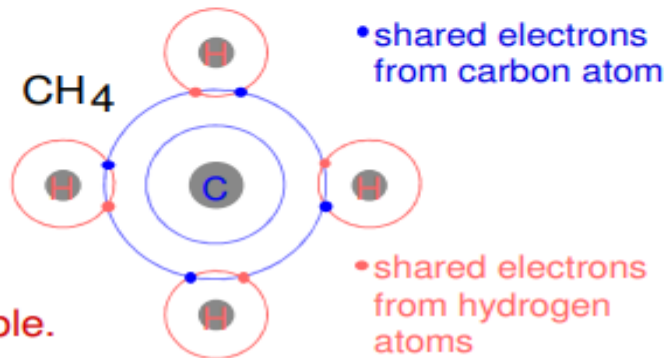


- Example2: CH_4

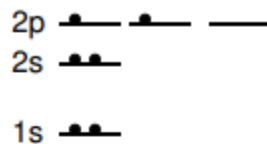
C: has 4 valence e,
needs 4 more

H: has 1 valence e,
needs 1 more

**Electronegativities
are same or comparable.**



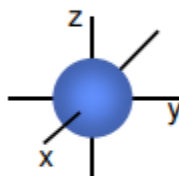
atomic orbitals for carbon:



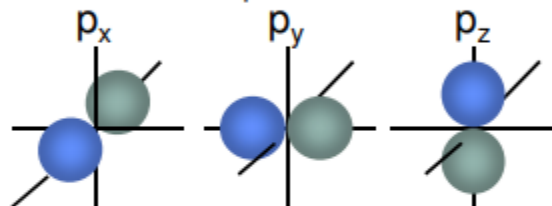
4 valence electrons but two different types orbitals.
H's on CH_4 should be equivalent.

Atomic Orbitals

an s-orbital

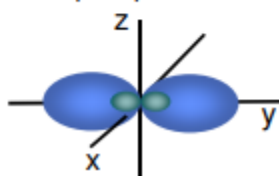


the three p orbitals

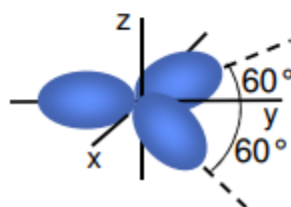


Hybridization

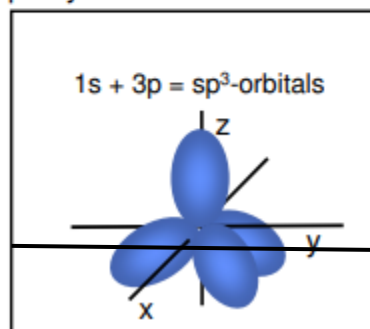
$1s + 1p = sp$ -orbitals



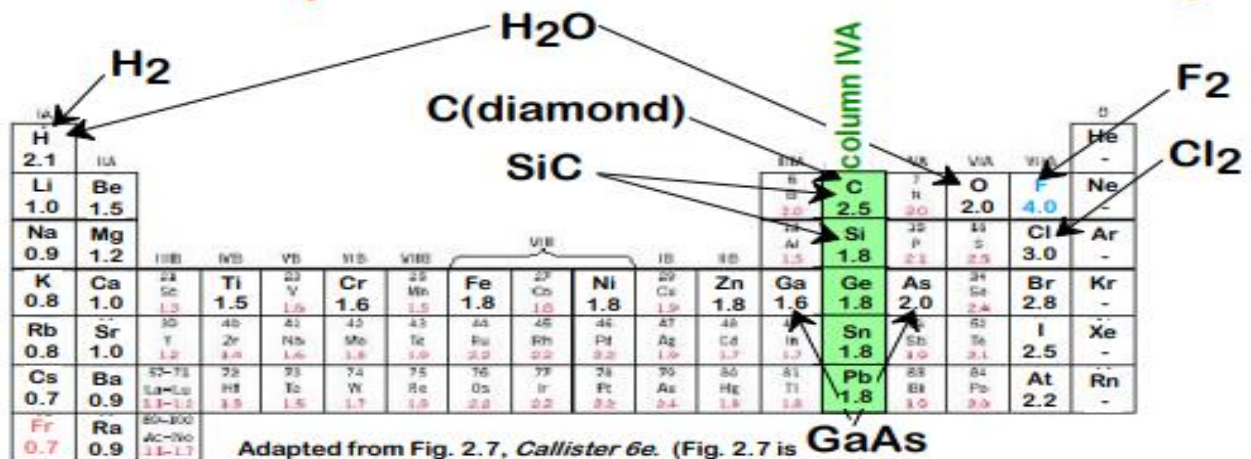
$1s + 2p = sp^2$ -orbitals



sp^3 hybridization for C in CH_4



Examples: Covalent Bonding

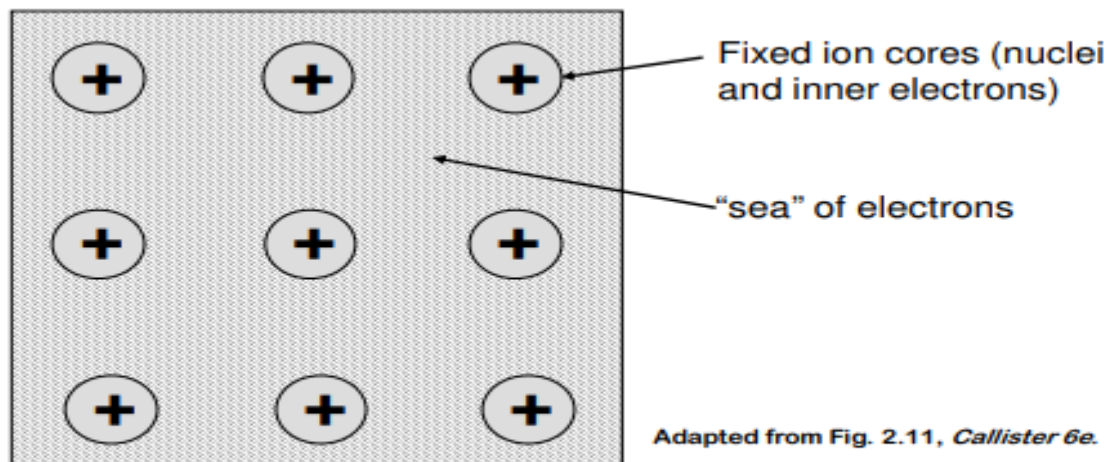


Adapted from Fig. 2.7, Callister 6e. (Fig. 2.7 is adapted from Linus Pauling, *The Nature of the Chemical Bond*, 3rd edition, Copyright 1939 and 1940, 3rd edition. Copyright 1960 by Cornell University. From Callister 6e resource CD.

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

Metallic Bonding

- Arises from a sea of **donated valence electrons**



Adapted from Fig. 2.11, Callister 6e.

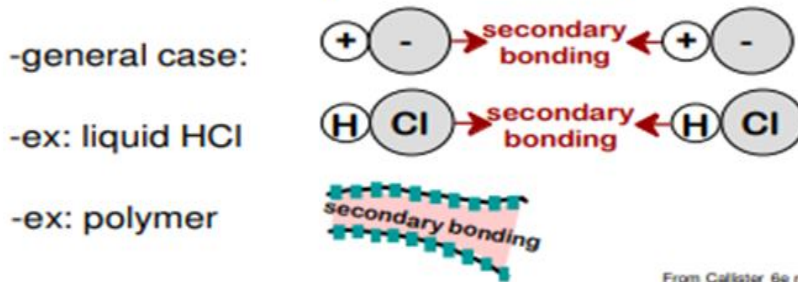
- Primary bond for **metals** and their **alloys**.
- Large atomic radius and small IP will more likely lead to metallic bonding.

- **Valence** electrons are completely delocalized to form an electron cloud, in which positive ionic cores are embedded.
- The remaining nonvalence electrons and atomic nuclei form “ion cores”, which possess a net positive charge equal in magnitude to the total valence electron charge per atom.
- The metallic bond is nondirectional.
- Metallic bonding is found in the periodic table for Group IA and IIA elements.
- Electron delocalization is the origin of good electrical and thermal conductivities in metals. (Ionically and covalently bonded materials are typically electrical and thermal insulators, due to the absence of large numbers of free electrons) .

Secondary Bonds: Intermolecular Forces

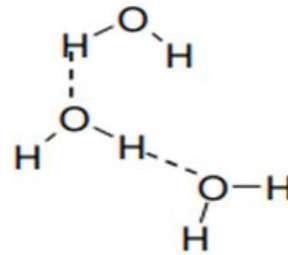
- **Secondary, Van der Waals, or physical bonds** are weak in comparison to the primary bonds.
- Secondary bonding exists between virtually all atoms or molecules, but its presence may be obscured if any of the three primary bonding types is present.
- Secondary bonding forces arise from atomic or molecular **dipoles**. An electric dipole exists whenever there is some separation of positive and negative portions of an atom or molecule.
- Dipole interactions occur between induced dipoles, between induced dipoles and polar molecules (which have permanent dipoles), and between polar molecules.
- Hydrogen bonding, a special type of secondary bonding, is found to exist between some molecules that have hydrogen as one of the constituents.

- **Dipole-dipole interaction:** secondary bond between molecules with permanent dipole moments



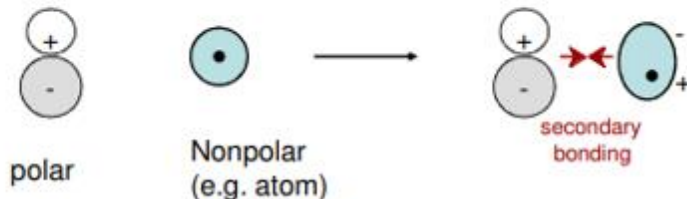
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- **Hydrogen bonding**



- **Polar molecule-induced dipole interaction:**

Polar molecules (with asymmetric arrangement of positively and negatively charged regions) can induce dipoles in adjacent nonpolar molecules



- **Fluctuating dipoles**

Constant vibrational motion can cause distortions of electrical symmetry

