

METALS

METALLIC CHARACTER

Metals are electropositive species that tend to lose electrons when little energy is given. M is about to show the metal atom;



The greater the tendency to lose electrons, the higher the electropositive and the higher the metallic character. Since the tendency to lose electrons depends on the ionization energy, the metallic character increases when we go down and the metallic character decreases when we go right in the periodic table. Accordingly, Na and Mg in the same period show more metallic properties than Si and Si more than Cl. In the fourth group, C nonmetal, Si and Ge are semi-metal, Sn and Pb are metallic. The most electropositive element in the periodic table is Cs with the highest metallic character and F is the most nonmetallic element.

The metals in the periodic table

- 1. Alkali metals: Elements other than hydrogen group 1A (s-block).*
- 2. Alkaline earth metals: 2A group (s-block) elements.*
- 3. Earth metals: Except for boron, they are 3A group elements.*
- 4. Transition metals: These are group B (d-block) elements between the 2A group and the 3A group. It starts with 3B and ends with 2B. The 8B group consists of three element groups side by side. In the 8B group, vertical similarities are more important than horizontal similarities. The f-block elements of the periodic table are called internal transition elements. Internal transition metals in period 6 are called lanthanides and internal transition metals in period 7 are called actinides. Lanthanides are active metals while actinides are radioactive metals.*
- 5. Group 4A metals: Sn, Pb and Fl.*
- 6. Group 5A metals: Bi and Mc.*
- 7. Group 6A metal: Lv.*

PHYSICAL PROPERTIES OF METALS

In order to be a metal for an element, it must have 6 physical properties:

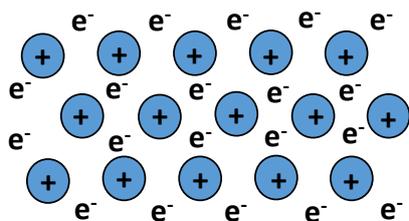
- 1. A metal has very high electrical and thermal conductivity.*
- 2. A metal has a characteristic metallic gloss.*
- 3. A metal shows thermoionic and photoelectric properties.*
- 4. A metal has a crystal structure and generally has a cubic close packed cubic system (face-centered cubic), a hexagonal close packed system, and an body-centered cubic system.*
- 5. A metal has the ability to be forged and drawn properties.*
- 6. A metal easily form an alloy.*

THEORIES RELATED TO BONDING IN METALS

- 1. Free electron theory*
- 2. Valence bond theory*
- 3. Molecular orbital theory*

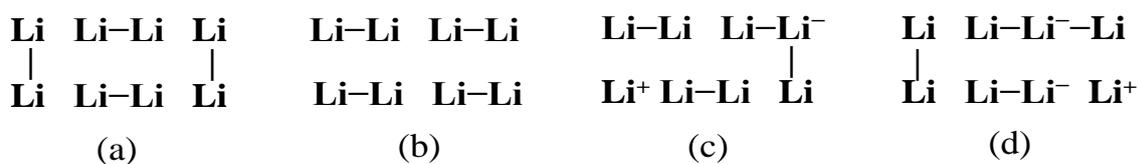
Free electron theory

In the 1900s, Drude considered the metal as a lattice in which electrons move and liken the motion of electrons to the free motion of gas molecules. This idea was developed in 1923 by Lorentz. Lorentz, taking into account the very low ionization energies of valence electrons, defined metals as the lattice of solid clusters of positive ions, which have placed free valence electrons.



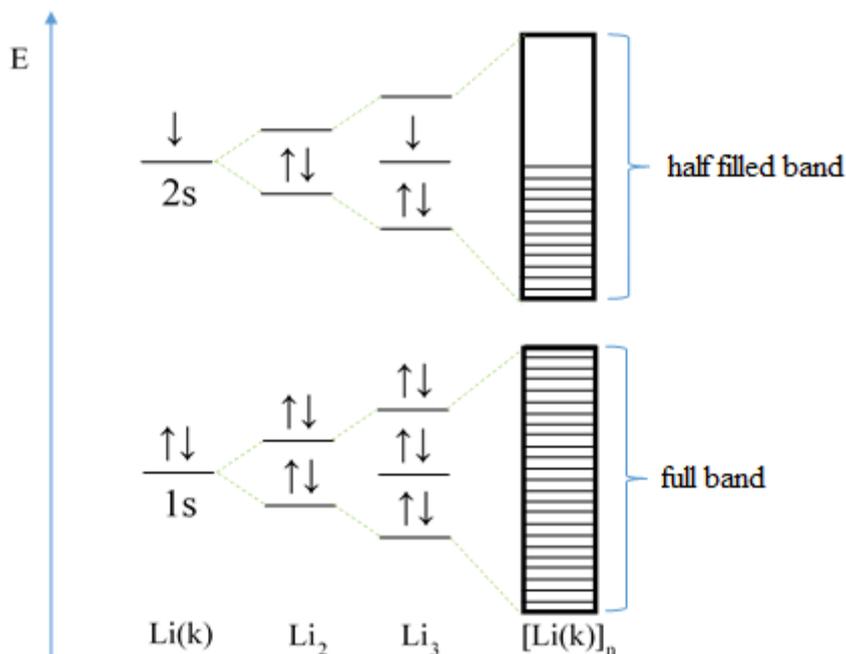
Valence bond theory

Let us examine a Li atom with a coordinate number of 8 in the Li crystal, which has an body-centered cubic structure. The Li atom has a valence electron and can only give a two-covalent bond with one of the neighboring Li atoms. This atom in the crystal must be connected equally to other neighboring Li atoms. In this case, species (a) and (b) and similar species can be formed. A Li atom can only form two bonds if ionized.

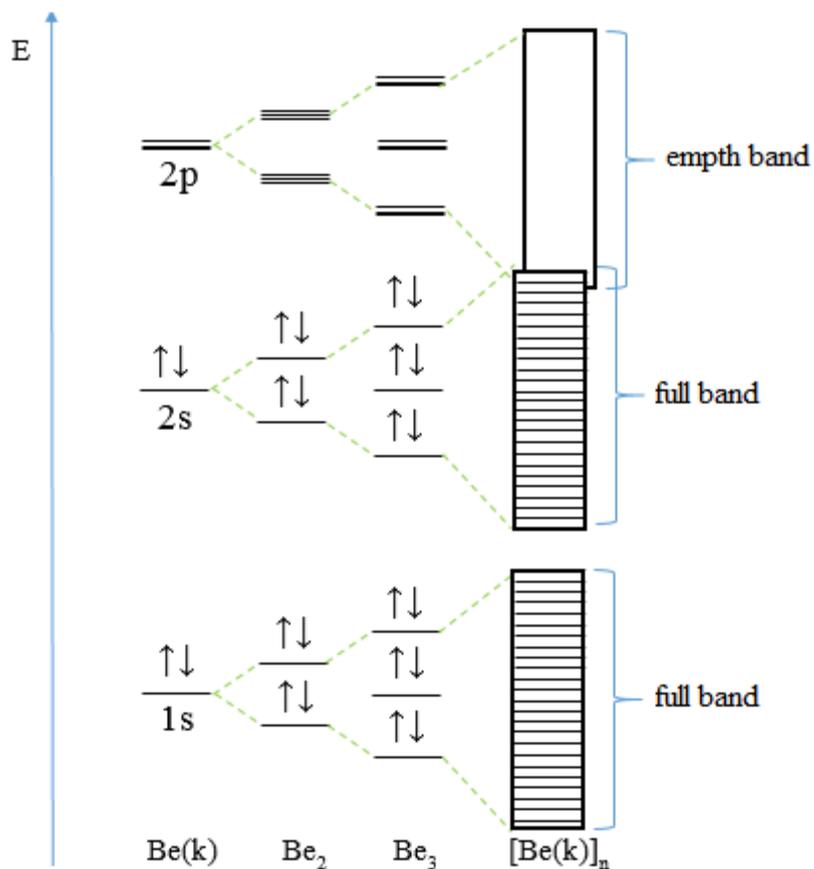


Molecular orbital theory

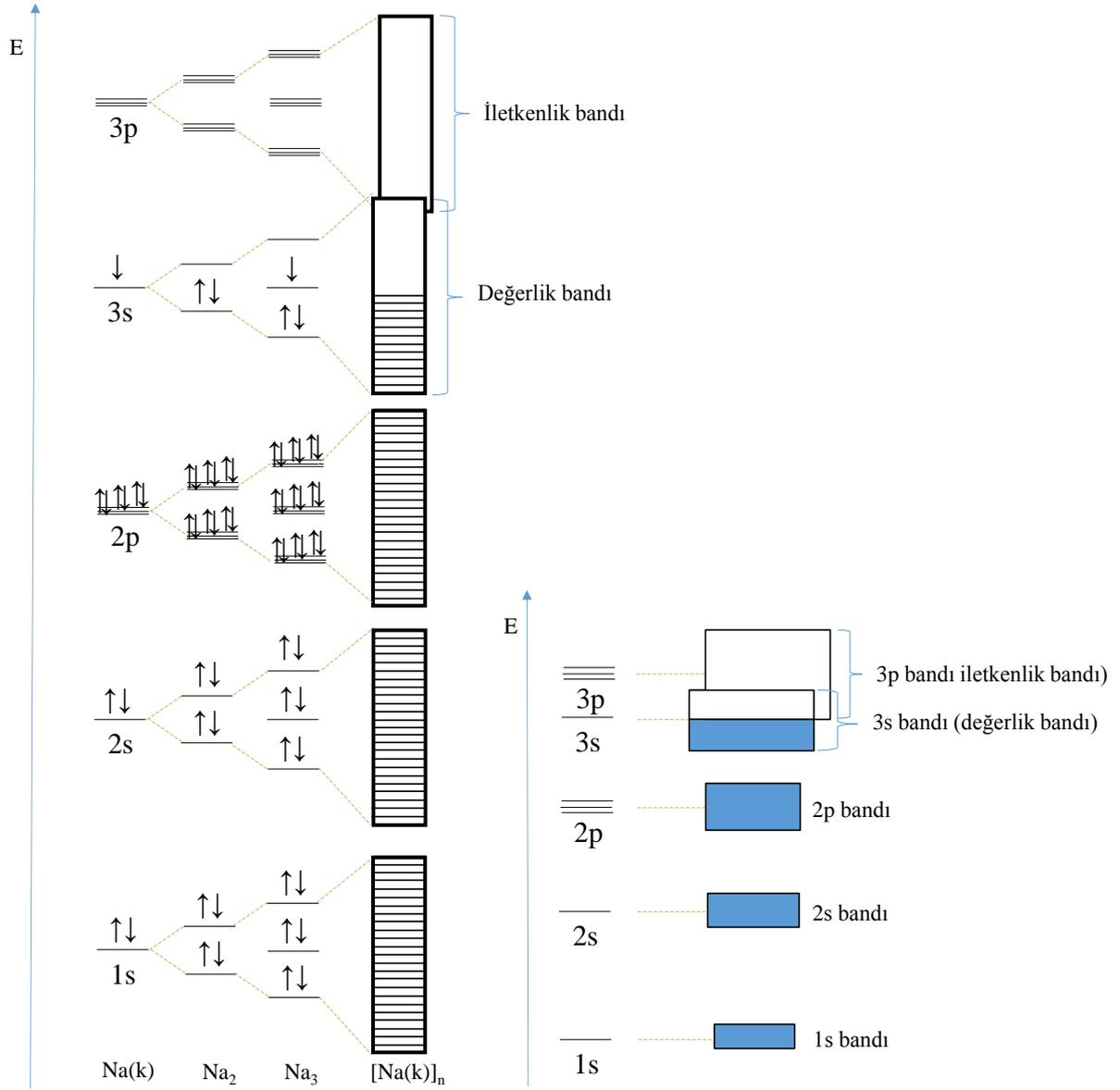
The application of molecular orbital theory to crystal structures is known as band theory.



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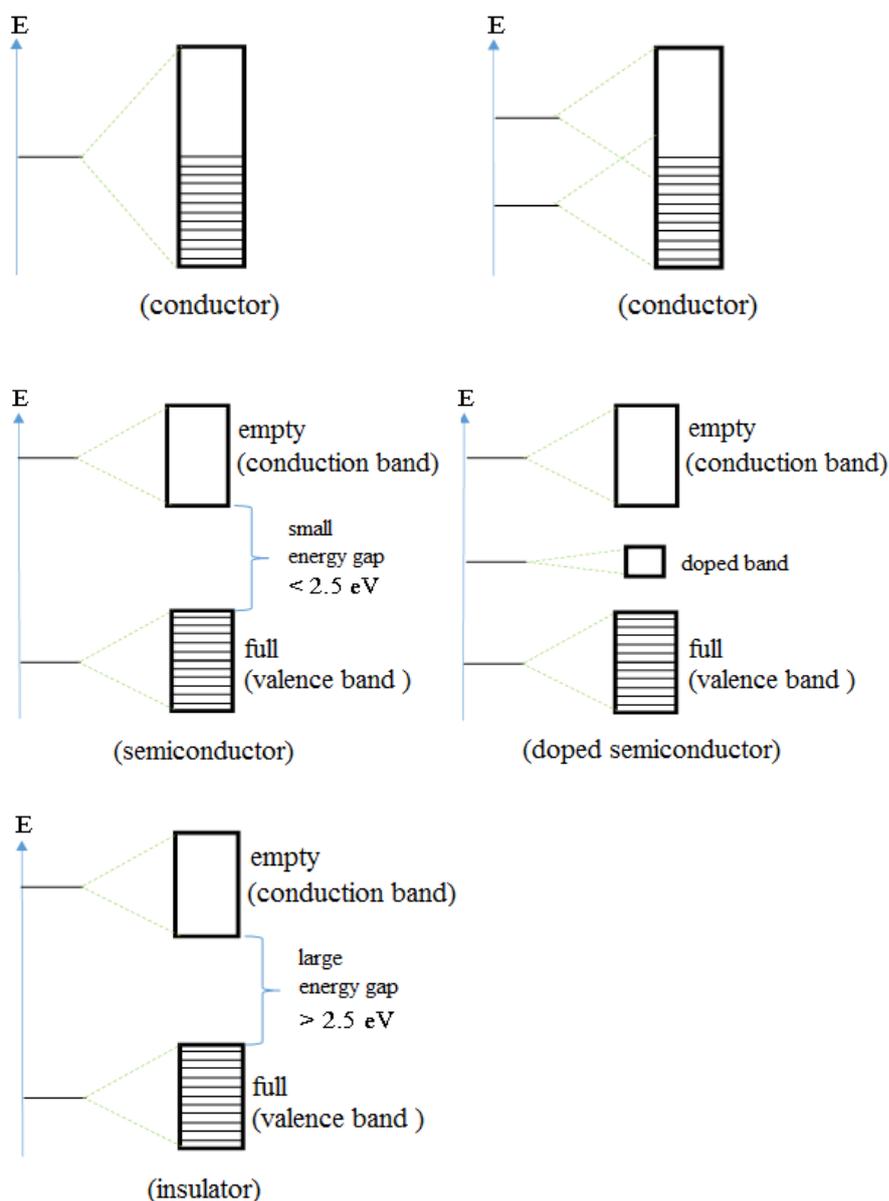


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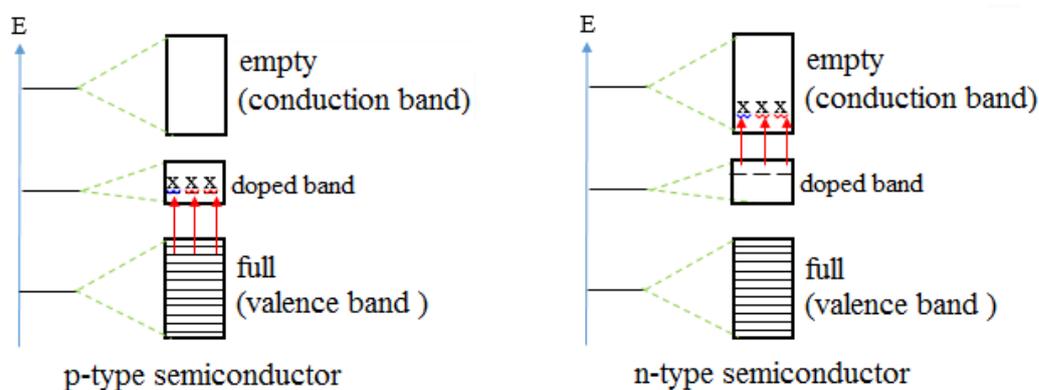
CONDUCTORS, SEMICONDUCTORS AND INSULATORS, SUPERCONDUCTORS

In **conductors**, the valence band is partially filled or the valence band and the conductivity band coincide. In other words, there is no significant energy gap between the full and empty molecule orbitals, and the electron transition can easily take place. In **insulators**, the valence band is full and therefore no electron transfer is possible within the band. There is also a significant energy gap between the valence band and the conduction band. For this reason, electrons cannot pass through this empty band from which they can move freely. **Semiconductors** are similar to insulators, but the energy gap between the fully filled valence band and the empty conduction band is so low that a small number of electrons pass from the valence band to the empty conduction band.



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An n-type semiconductor is created when pure semiconductors, like Ge, are doped with pentavalent elements (P). When a pentavalent atom takes the place of a Ge atom, four of its electrons bond with four neighbouring Ge atoms. However, the fifth electron remains loosely bound to the parent atom. This electron can move in the lattice even at room temperature. When a semiconductor is doped with a pentavalent atom, electrons are the majority charge carriers. On the other hand, the holes are the minority charge carriers. Therefore, such extrinsic semiconductors are called n-type semiconductors. A p-type semiconductor is created when trivalent elements are used to dope pure semiconductors, like Ge. When a trivalent atom takes the place of a Ge atom, three of its electrons bond with three neighbouring Ge atoms. However, there is no electron to bond with the fourth Ge atom. This leads to a hole or a vacancy between the trivalent and the fourth Ge atom. This hole initiates a jump of an electron from the outer orbit of the atom in the neighbourhood to fill the vacancy. This creates a hole at the site from where the electron jumps. In simple words, a hole is now available for conduction. When a semiconductor is doped with a trivalent atom, holes are the majority charge carriers. On the other hand, the free electrons are the minority charge carriers. Therefore, such extrinsic semiconductors are called p-type semiconductors.



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*Substances conducting electricity with almost no resistance are called **superconductors**. In other words, the electrical resistance of a superconductor is zero or very close to zero. Therefore, the electric current is carried without loss of energy and theoretically the current is transmitted without limits. The high electrical conductivity of metals at normal temperatures is further enhanced by lowering the temperature. In 1919, Kammerling Onnes discovered superconductivity while studying Hg in liquid He. Onner found that metals such as Hg and Pb are superconductors at temperatures close to absolute 0. There is a critical temperature T_k , where the electrical resistance of the materials decreases abruptly and superconduction is observed. Above the critical temperature, the superconductivity is terminated. Some metals become superconducting at temperatures close to the liquid He temperature (usually below 10 K).*

Later, Meissner and Ochsenfeld found that superconductors do not allow the magnetic field to pass through. This effect, called the Meissner effect, increases the rise in air. Superconductors repel magnetic fields from unpaired electron pairs. The superconductors are therefore diamagnetic.