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Unit I B. Metallic Bonding

Introduction.
- Metals have high electrical and thermal conductivities.
- metals have high M.Pt. & B.Pt.
- They shows property of malleability and ductility.
- They are crystalline in nature.
- They have high Co-ordination number.
- They have metallic bond.

Def of metallic bond

Theories of metallic bonds
(i) Free electron Theory OR Electron sea theory
(ii) Valance bond Theory OR Resonance Theory
(iii) Band Theory OR molecular orbital Theory

(1) Free Electron Theory OR Electron sea Theory:-
- This theory was putforward by Drude and Lorentz.
- This theory is based on two important properties of metals.
(a) Unpaired electrons (1, 2 or 3) in the valance shell.
(b) Low ionisation potential (energy) of metals due to which electron can easily lost.

According to this theory,
- Metal atom loose its outermost electrons and converted into positive ions
- Therefore metal structure consist of +ve charge metal ions and free electrons.
- The +ve charge metal ions are called as Kernels and free electrons are called as sea of electrons.
- The combined force of attraction between mobile electrons and +ve charge metal ions is called metallic bond.
- The force of attraction between mobile electrons and metal ion is uniform in all three dimentions.

- But metallic bond is different than that of covalent bond due to
(a) It is non-directional in nature.
(b) It is weaker than covalent bond.
But strength of metallic bond increases with increase in no. of valance electrons.
eg The strength of metallic bond in Na, Mg, Al increase in following order with increase in number of valance electrons as

$$Na < Mg < Al$$

valance electron 1 2 3 → metallic bond strength increases

Properties of metals on the basis of Free electron theory:

(a) Electrical and Thermal conductivity:

This property depends upon number of valance electrons present in metal.
- When some potential is applied, then electrons are flow in the direction of applied field. Due to this directed flow of electrons, the current flows from one point to another. Therefore metals are good conductor of electricity.

Similiary, when piece of metal is heated at one end, the electrons present there aquire heat energy and transfer to other end. Therefore metals are good conductor of heat.

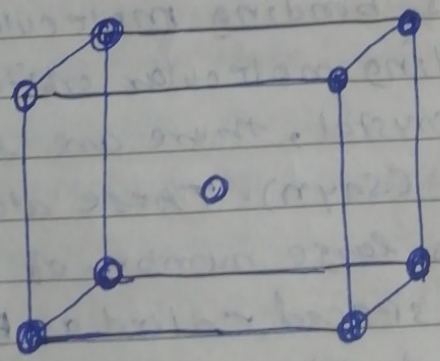
(b) Malleability and ductility:

The property of metals to form thin sheet on hammering is called as malalleability
The property of metals to form wire (or to drawn into wire) is called as ductility.

we know that, In metals structure, the metal ions are embedded in the sea of electrons. When metal is hammered, the metal ion layers slide over each other and forms a thin sheet and electrons acts as cushion (or adjusted accourdingly). and similarly wire can be obtained.

(1) **Metallic luster:**
The metals have typical shining luster. This is due to presence of free electrons present in the metal. When light is fall on clean surface of metal, the free electrons absorb light energy and ~~re-emitted~~ goes to higher energy level (excited state) but higher energy level is ~~not~~ unstable and electrons can not stay longer time their and immediatly come back to ground state and reemitted in the form of light. This is responsible for shining luster.

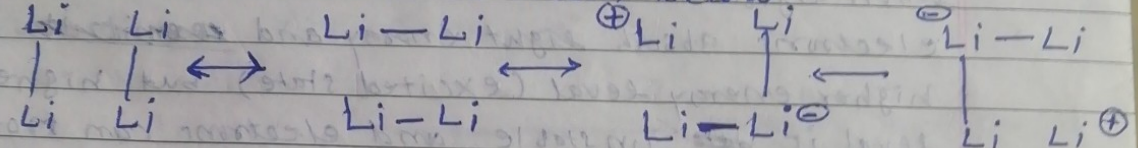
(2) **Valance Bond Theory or Resonance Theory**
- This theory was given by Pauling.
- This theory considered covalent bond between two metal atoms.
- The metal atom is surrounded by definite number of nearest metal atoms in the metallic crystal lattice.
eg Lithium atom is surrounded by 8 neighbouring lithium atoms. These lithium atoms are joined by covalent bonds.



The electronic configuration of Li is $1s^2 2s^1$. Each lithium atom has one valance electron. Therefore two lithium atoms share one electron each and forms single covalent bond. But this bond is not permantly established. It is immediatly broken and a new bond is formed between other lithium atoms. That means bond is continuously resonating.

eg

If we consider only four lithium atoms we can show the resonating bonds as shown below.



This type of resonance structure is present throughout the structure.

But theory fails to explain thermal and electrical conductivity, metallic lustre.

③ **Molecular orbital theory or Band Theory**—

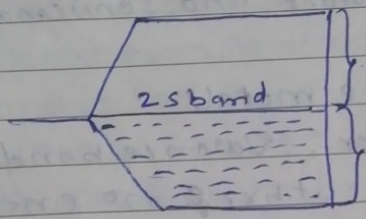
This theory considered that all the electrons in the metal belong to metal atom in the metallic crystal.

Band:

~~Band is~~ The set of large no. of closely spaced molecular orbitals in a metallic crystal is called as band

- We know that, when two atomic orbitals undergo linear combination then two molecular orbitals are formed one is bonding molecular orbitals and another is antibonding molecular orbitals.
- In the metallic crystal, there are large numbers metal atomic orbitals (say n). These atomic orbitals ~~undergoes~~ Combined and forms large number of molecular orbitals, which are closedly spaced called as **Band**.
- eg ① In case of lithium, [E.C. is $1s^2 2s^1 2p^0$], there are three bands; The lowest energy 1S band which is

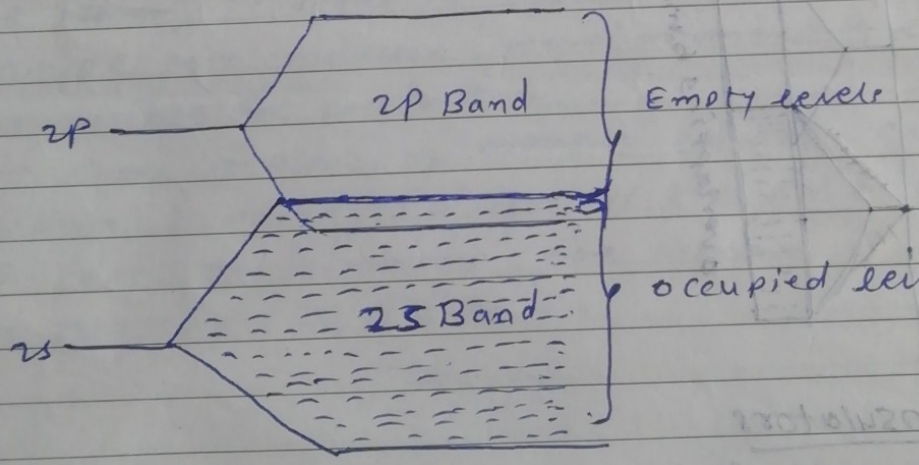
fully filled, the next is 2s band which is half filled and 2p band which is vacant.
- Actually 2p band partly overlap with 2s band.
- There is an energy gap between filled 1s band and half filled 2s band. This energy gap is called as forbidden energy gap. and electrons are not allowed to go here.



Half filled 2s band in Li

- eg 2

In case of beryllium, [E.C. $1s^2 2s^2 2p^0$], there are three bands namely fully filled 1s band, Fully filled 2s band and vacant 2p band which is partially overlap with 2s band.



The lower energy state molecular orbitals are called as valance band and
Higher energy state molecular orbitals are called as conduction band.
Therefore in Be, 2s is valance band and 2p is conduction band.

Conditions for conduction of electricity

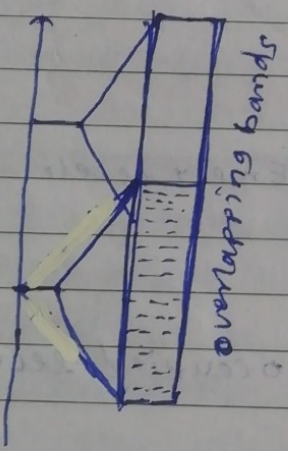
For conduction of electricity, the potential difference is applied and electrons from lower energy molecular orbital is excited to higher energy molecular orbitals of same band or higher band.

on the basis of band theory we can explain the nature of conductors, insulators and semiconductors.

Conductors or True metals

In case of conductor, valance band and conduction band overlap each other & no energy gap between them. Therefore there is good electrical conduction.

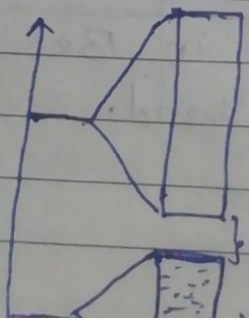
- When potential difference is applied, the electrons in lower energy MO are excited to higher energy MO of same band due to this conduction occurs.



Insulators

In case of insulator, the energy gap between valance band and conduction band is very large

- When potential difference is applied, electrons cannot passed from valance band to conduction band. Therefore substance cannot conduct electricity and acts as insulator



Semiconductors

The substance which acts as insulator at absolute zero temp. and conductor at ordinary temp. is called as semiconductor.

There are two types of semiconductor, namely intrinsic semiconductor and extrinsic semiconductor.

Intrinsic semiconductors are poor conductors at ordinary temperature but conductivity increases with increase in temp.

- When temp. increase electrons from valance band jump to conduction band by crossing barrier and causes conduction.

In extrinsic semiconductor, some impurity is added to insulator. The process of adding of impurity is called as dopping.

→ When impurity of group-15 elements (eg Arsenic or Antimony) is added to silicon or germanium, we get n-type semiconductor. Here moment of electron is responsible for conduction.

→ When impurity of group-13 elements (eg gallenium Indium) is added to silicon or germanium, we get p-type semiconductor. Here moment of positive holes is responsible for conduction.

3rd 5th
B N
Al P
Ga As
In Sb
Tl Bi

—x—