Chemistry Study Materials for Class 12
(NCERT Based Notes of Chapter- 01)

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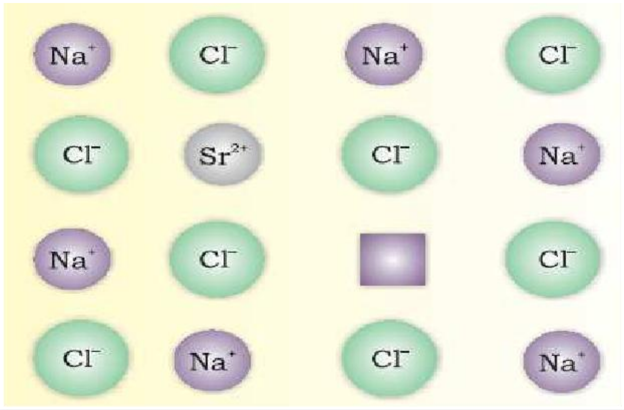
The Solid State

Imperfections in solids (Crystal Defects)

***(b) Impurity Defects*:** It is the defect arising due to the presence of foreign particles in a crystal. For example if molten NaCl containing a little amount of $SrCl_2$ is crystallised, some of the sites of Na^+ ions are occupied by Sr^{2+}. Each Sr^{2+} replaces two Na^+ ions. It occupies the site of one ion and the other site remains vacant. The cationic vacancies thus produced are equal to the number of Sr^{2+} ions. Another similar example is a solid solution of $CdCl_2$ and AgCl.



Properties of solids

1) ***Electrical properties*:** Based on the electrical conductivity, solids are classified into three types:

i. **Conductors**: They are solids which allow the passage of electricity through them. Their conductivity ranges from 10^4 to 10^7 $ohm^{-1}m^{-1}$. Metals have conductivities in the order of 10^7 $ohm^{-1}m^{-1}$.

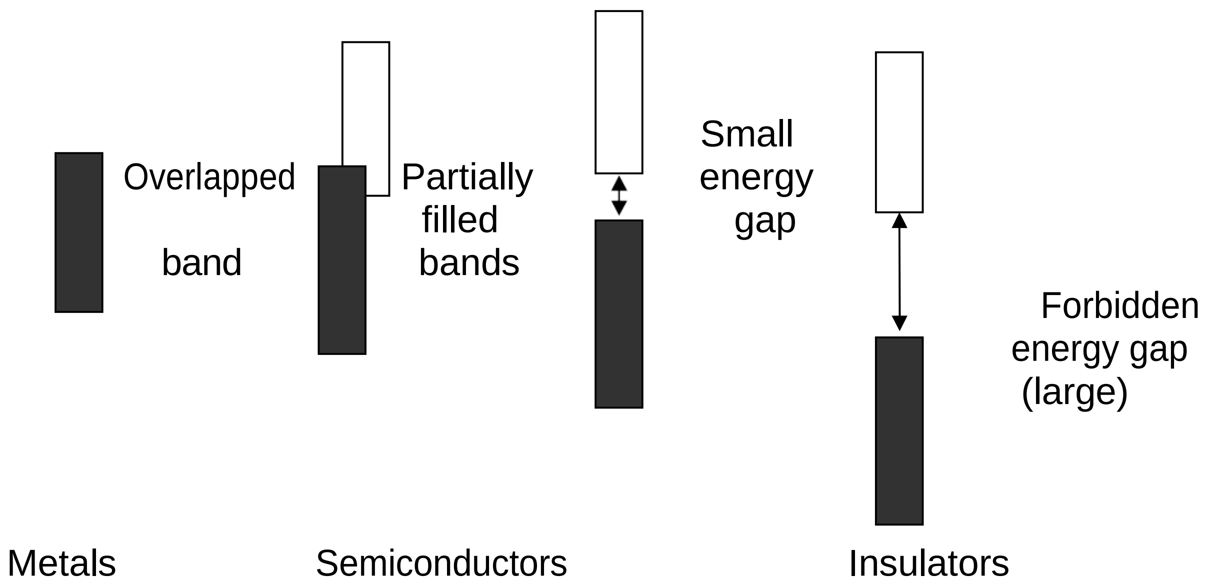
ii. **Semi-conductors**: They are solids which allow the passage of electricity only partially. Their conductivity ranges from 10^4 to 10^{-6} $ohm^{-1}m^{-1}$.

iii. **Insulators**: They are solids which do not allow the passage of electricity through them. Their conductivity ranges from 10^{-10} to 10^{-20} $ohm^{-1}m^{-1}$.

Conduction of Electricity in metals - Band Model

Metals conduct electricity in solid as well as in molten state. The conductivity of metals depends upon the number of valence electrons. The atomic orbitals of metals combine to form molecular orbitals, which are so closely spaced that they form a band. If this band is partially filled or it overlaps with a higher energy unoccupied conduction band, the electrons can flow easily under an applied electric field and the metal shows conductivity.

If the gap between filled valence band and the unoccupied conduction band is large the electrons cannot jump to it and such substances act as insulators.



Conduction of Electricity in semi-conductors

In the case of semiconductors, the gap between the valence band and the conduction band is small. So some electron may jump from valence band to conduction band and show some conductivity. Their conductivity increases with rise in temperature, since more electrons can jump to the conduction band. Such semiconductors are also called *intrinsic semiconductors*. E.g.: Si, Ge etc.

The conductivity of intrinsic semiconductors is very low. Their conductivity can be increased by adding an appropriate impurity. The process is called *doping*. Addition of impurities creates electronic defects in them. Such semiconductors are called *extrinsic semiconductors.* Doping can be done by the addition of either *electron rich impurity or electron deficit impurity.*

a) *Doping by electron rich impurity:*

When a group 14 (which contains 4 electrons in the valence shell) element like Si or Ge is doped with a group 15 element (which contains 5 electrons in the valence shell) like P or As, four electrons are used for the formation of covalent bonds and the fifth electron becomes free. The presence of this delocalized electron increases the conductivity and hence silicon doped with electron rich impurities is called *n-type semiconductor*.

b) *Doping by electron deficient impurity:*

When a group 14 (which contains 4 electrons in the valence shell) element like Si or Ge is doped with a group 13 element (which contains 3 electrons in the valence shell) like B, Al, or Ga, the three electrons are used for the formation of covalent bonds and the fourth valence electron is missing. This creates an electron hole or electron vacancy. An electron from a neighbouring atom can come and fill the electron hole. So the position of the hole is moved in the direction opposite to that of the electron has moved. Under the influence of electric field, electrons would move towards the positively charged plate through electronic holes. It would appear as if electron holes are positively charged. This type of semiconductors are called *p- type semiconductors*.

A large variety of solids which have lattices similar to Ge or Si have been prepared by the combination of groups 13&15 or 12&16. E.g. for 13and15 group compounds are InSb, AlP & GaAs. They are used as semiconductors. E.g. for 12 and 16 group compounds are ZnS, CdS, CdSe & HgTe.

2) ***Magnetic properties***

Every solid has some magnetic properties associated with it due to the presence of electrons. Each electron in an atom behaves like a tiny magnet. Electron being a charged particle and due to spin and orbital motions, has a permanent spin and orbital magnetic moment. The magnitude of this magnetic moment is very small and is a measured in the unit called Bohr Magneton (μ_B). (1 $\mu_B = 9.27\times10^{-24}$ Am^2 (ampere- metre square)).

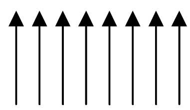
Based on the magnetic properties, solids can be classified into *five* types.

1. Diamagnetic Substances: These are weakly repelled by an external magnetic field. Diamagnetism arises due to the presence of only paired electrons. Pairing of electrons cancels their magnetic moments and so they have no net magnetic moment. E.g.: H_2O, NaCl, Benzene (C_6H_6)

2. Paramagnetic Substances: They are weakly attracted by an external magnetic field. Paramagnetism is due to the presence of one or more unpaired electrons. They have a net magnetic moment. They lose their magnetism in the absence of external magnetic field. So they are temporary magnets.

Eg: O_2, Cu^{2+}, Fe^{3+}, Cr^{3+} etc.

3. Ferromagnetic Substances: They are very strongly attracted by a magnetic field and can be permanently magnetised. In solid state, the metal ions of ferromagnetic substances are grouped together into small regions called *domains*.

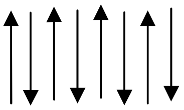


In the absence of an external magnetic field, these domains are randomly oriented. When the substance is placed in a magnetic field, all the domains get oriented in the direction of the magnetic field and a strong magnetic effect is produced.

This ordering of domains do not change even when the external magnetic field is removed and so they become permanent magnets.

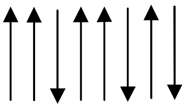
Eg: Fe, Co, Ni, Gd (Gadolinium), CrO_2 etc.

4. **Anti-ferromagnetic Substances**: Here the domains are appositively oriented and cancel each other. So they have no net magnetic moment.



Eg: MnO

5. **Ferrimagnetic Substances**: Here the domains are arranged in opposite directions but in unequal numbers. So they have a net magnetic moment.



Eg: Fe_3O_4 (magnetite) and ferrites like $MgFe_2O_4$, $ZnFe_2O_4$ etc

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