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Topper Handwritten Notes
Basic of Material Science
By-Suneel Tiwari Sir

- Theory
- Explanation
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#Basic of Material science#.

→ Introduction and atomic bonding (EC+EE)

→ crystallography (EC+EE)

→ Electric properties of materials
  - → conductor
  - → Insulator
  - → semiconductor

  } EC+E

→ magnetic properties of materials (EC+EE)

→ mechanical properties of materials (video)

→ ceramics (EC+EE).

→ polymers

→ composites (video)

→ phase diagram and alloys.

source.

① class notes

② Theory book.

Telegram

anunaad22

8 march 2025

Material science

→ material science involves investigating the relationship bet^n the structure and properties of material.

→ material sc. does not deal with study of strength and stiffness (or other properties) behaviour of Engg component such as buildings machines, automobil etc, rather it deals with the study of strength & stiffness behaviour (or other properties) of the materials with which these engg component has been design.

Material :- material can be defined as something that consist of matter (occupy some space and has some mass). It is the stuff by which something can be made.

→ Engg materials can be broadly classified as

1. Metals and alloys.
2. ceramics
3. polymers
4. Composite
5. Advanced materials
   - semiconductors
   - Biomaterials
   - smart materials
   - Nanomaterials.

structure

structure of a material usually refereds to the arrangement of it's internal components

1. subatomic structure
2. Atomic structure
3. Nanostructure
4. Microstructure → The structure which can be observed with the help of optical microscope.
5. Macrostructure → The structure which can be observed with naked eyes.

Nuclear structure { NMR

properties of materials.

a property is a material trait in terms of the kind and magnitude of response to a specific imposed stimulus (excitation)

Generally, defⁿ of prop. of are made independent of material shape and size.

Mechanical property, Electrical property, magnetic property optical property, Thermal property, Deteriorative property

SiO_2 → Slowly cool → Quartz (single crystal material).

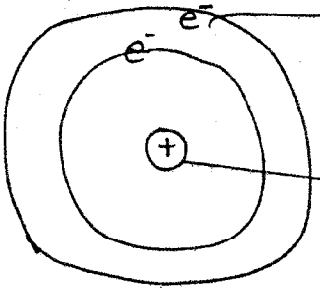
SiO_2 → Rapidly cool → Glass (Amorphous material).

processing → structure → property → performance

Atomic Bonding :-

→ matter is made of some tiny indivisible structures known as as "atom".

→ atoms can neither be created nor destroyed



e⁻ → Negatively charged particle.

charge = -1.6×10^{-19} C

mass = 9.1×10^{-31} kg.

Nucleous

it contains protons + neutrons.

+vely charged particle

charge = 1.6×10^{-19} C

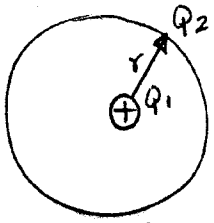
mass = 1.67×10^{-27} kg

↳ Electrically neutral particle.

charge = 0

mass = 1.67×10^{-27} kg.

Magnitude of e⁻ charge $q = 1.6 \times 10^{-19}$ C.



$$F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$$

↳ Electrostatic Force (coulombic force).

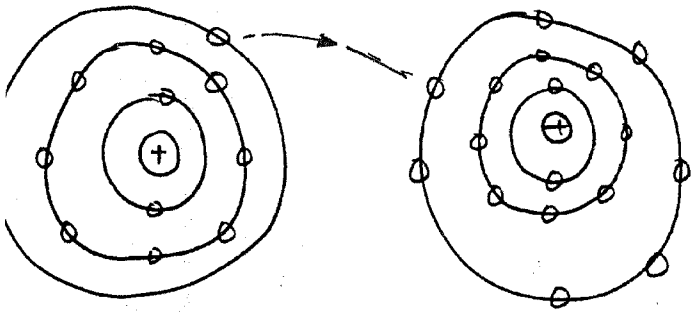
chemical bond :- The binding force betⁿ atoms or molecule is known as chemical bond.

chemical Bond.

- primary bond.
  - → Interatomic bond
  - → Electrostatic force
  - → strong and stable
    - Ionic bond
    - covalent bond
    - metallic bond
- Secondary bond
  - → Intermolecular bond.
  - → wander waal's force.
  - → weak and unstable

Ionic Bond :-

$Na \rightarrow 11$ ° 2,8,1 $\quad Cl \rightarrow 17$ 2,8,7



cation

$Na \longrightarrow Na^+ + e^-$

$Cl + e^- \longrightarrow Cl^-$ (anion)

$Na^+ + Cl^- \longrightarrow NaCl$

Ionic bond is the electrostatic force ber^n cation and anion

$r_C < r_A$

→ Ionic bonds are non-directional bonds i,e the magnitude of bond is equal in all dir^n around an ion. it follows that

→ for ionic materials to be stable all +ve ions must have as nearest neighbour -vely charged ion in a 3-D scheme and vice versa.

→ Ionic bonds are generally formed ber^n metallic and non metallic elements. metallic elements have tendancy to easily give up their outer orbit e$^-$ so these form cations.

→ Non metallic elements have tendancy to take e$^-$ so these forms anions. so ionic bond is basically the coulombic force ber^n the cation and anion hence the it is the strongest bond among all primary bonds

→ cations are smaller than anions.

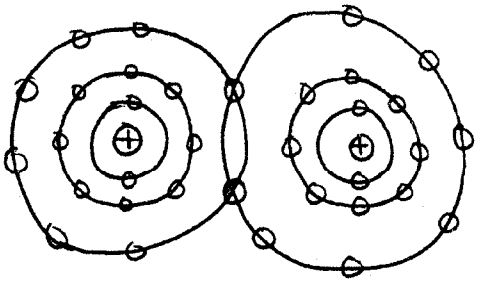
→ ionics material are inorganic
→ crystalline in nature
→ High strength and Hardness
→ low ductivity and malleability
→ High britteness
→ Electrically and thermally insulator.
→ Bonding energies which generally range betⁿ 600 to 1500 KJ/l are relatively large hence high melting temperature.

covalent bond :- Formed by sharing of electrons among the atoms.

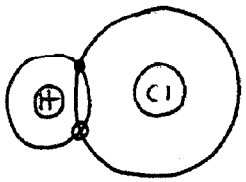
covalent bonds are directional bonds.

- It is between specific atoms and may exist only in the direction between atom and another that participates in electron sharing.

Cl → 17 2,8,7



→ Non polar covalent bond.



(Ionic + covalent)

polar covalent bond.

% Ionic character in polar covalent bond

$$= 100\left[1 - e^{-0.25(X_A - X_B)^2}\right]$$

where $X_A - X_B$ → is electronegativity difference between atoms A and B.

NOTE. if $X_A - X_B \geq 2$ → Ionic bond is formed.

GaAs
ZnS → polar covalent bond.

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covalent bond

polar covalent bond
- Bond is formed bet^n dissimilar atoms.
  Ex HCl, H_2O etc
- Bond has partial ionic character also (Ionic + covalent bond)

Non-polar covalent bond.
- Bond is formed between similar atoms.
  Ex. H_2 Cl_2 etc
- Bond is purely covalent.

· covalent compounds can be solid, Liquid gases.

covalent solids have
- High strength and Hardness
- High melting point
- Low ductility malleability → ability to converted into sheets under compressive stress.
- High brittleness

usually covalent compounds
usually covalent compounds are insoluble in water
Due to directional nature of bond covalent solids do not form closed pack structure.
The greater dist of e$^-$ from the nucleous higher is it's total energy
an e$^-$ orbiting very closed to the nucleous is tightly to the nucleous and pusseses small amount of energy so it is difficult to knock out this e$^-$ from it's orbit.
on the other hand an e$^-$ orbiting far from the nucleous in the outermost shell (valence orbit) is loosing bound to the nucleous and posseses greater amount of energy so this e$^-$ can be easy knock out it's orbit this is the reason why valence e$^-$ participate in bonding and chemical reaction etc.

Molecular orbital Theory.

consider hydrogen molecule.