AKSHAYA INSTITUTE OF TECHNOLOGY

Lingapura, Tumkur-Koratagere Road, Tumkur-572106.

To provide transformational technical competence by synergizing professional ethics and spiritual values to meet the global challenges and societal needs

Vision

DEPARTMENT OF CHEMISTRY

"APPLIED CHEMISTRY FOR ECE STREAM" [BCHEE102/202]

Mission

- To impart value-based quality technical education nurture the students to adopt themselves to the ever changing global needs
- To provide an experience the t inspires students to reach the highest level of accomplishment in their lives
- To provide an environment that enables students and faculty to make valuable contribution to the advancement of knowledge and creative practice of engineering

Prepared and verified by:

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Ms.Manasa.N. Assistant Professor

Department of Chemistry

Course Title:	Applied chemistry for ECE streams		
Course Code:	**BCHEE102/202**	CIE Marks	50
Course Type (Theory/Practical/Integrated)	Integrated	SEE Marks	50
Teaching Hours/Week (L: T:P: S)	2:2:2:0	Exam Hours	03+02
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Credits	04

Course outcomes

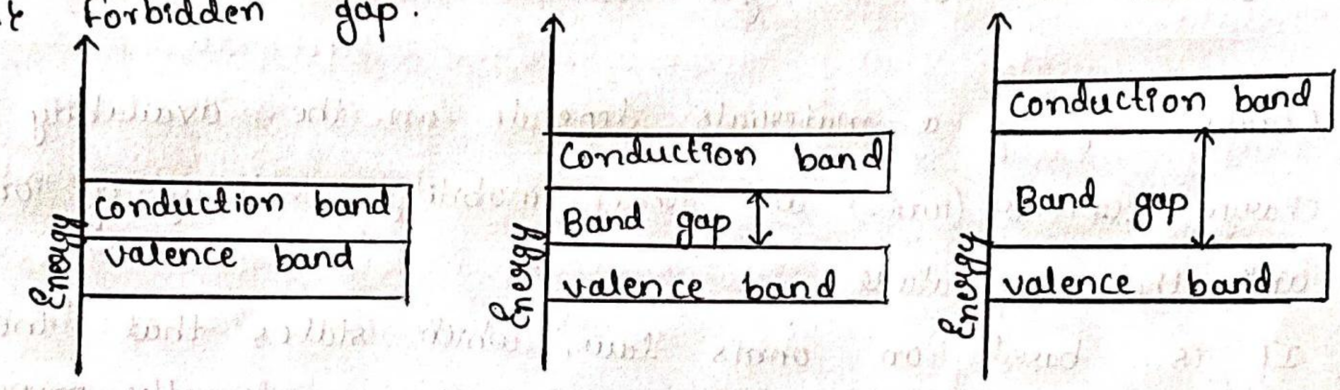
CO1	Identify the terms processes involved in scientific and engineering and application.
CO2	Explain the phenomena of chemistry to describe the methods of engineering processes
CO3	Solve the problems in chemistry that are pertinent in engineering applications
CO4	Apply the basic concepts of chemistry to explain the chemical properties and solution
CO5	Analyze properties and multi processes associated with chemical substances in disciplinary situations

MODULE : 1 : CHEMISTRY OF ELECTRONIC MATERIALS

Conductors, Semiconductors and Insulators :

Conductivity of materials can be explained on the basis of band theory. According to this theory, there are three types of bands namely

i) Conduction band
ii) valence band
iii) Forbidden gap.



Conductor   Semiconductor   Insulator

The band formed by a series of energy levels containing the valence electron is called valence band (VB)

* It is highest occupied energy band
* It may be completely filled or partially filled with electrons.

The next higher permitted energy band is called the Conduction Band (CB)

* It is lowest unoccupied energy band.
* It may be empty or partially filled with electrons.

FORBIDDEN BAND :

The energy gap between the VB and CB is called the forbidden energy gap or Forbidden band.

* It is formed by the series of non-permitted energy levels above the top of the VB and below the bottom of the CB.
* It is the amount of energy to be supplied to the electron in VB to get excited into the CB.

Conductivity of a materials depends on the availabity of charge carrier (ionic) and their mobility, valency of ions and the temperature.

It is based on ohm's law, which states that "the current (I) flowing through a conductor is directly proportional to the applied potential (E) and inversely proportional to the Resistance (R)"

i.e. $I = E/R$ or $E = IR$

The reciprocal of the resistane is conductance

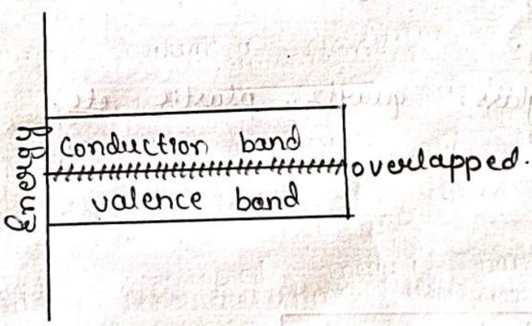
i.e. $C = 1/R$

Conductors :

A conductor or electrical conductor is a substance or materials that allows electricity to flow through it.

In conductors, electrical charge carriers (electrons or ions) move easily from atom to atom when voltage is applied and CB and VB are overlapped. Therefore there is easy flow of electrons and thus they are good conductors of heat and electricity.

ex :- metals, metal alloys, electrolytes and even Some non metals like graphite, water. other examples like silver, gold, platinum, aluminium, bars etc. copper

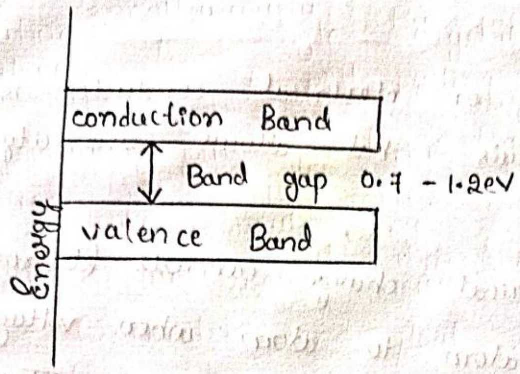


Conductors.

Semiconductor :

The Semiconductor is a class of solid whose electrical conductivity is between that of a conductor and an insulator. There is a small energy gap between CB and VB. There conductivity can be increased by increasing temperature or by doping

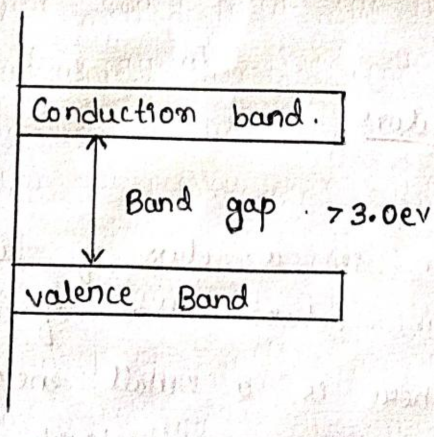
ex:- Silicon, germanium.



Insulators :-

Materials that doesn't allow electrical current or heat to pass through them are known as insulators. In insulator, due to the large forbidden gap between CB and VB. there is no easy flow of charge carriers. Therefore, they are bad conductors of heat and electricity.

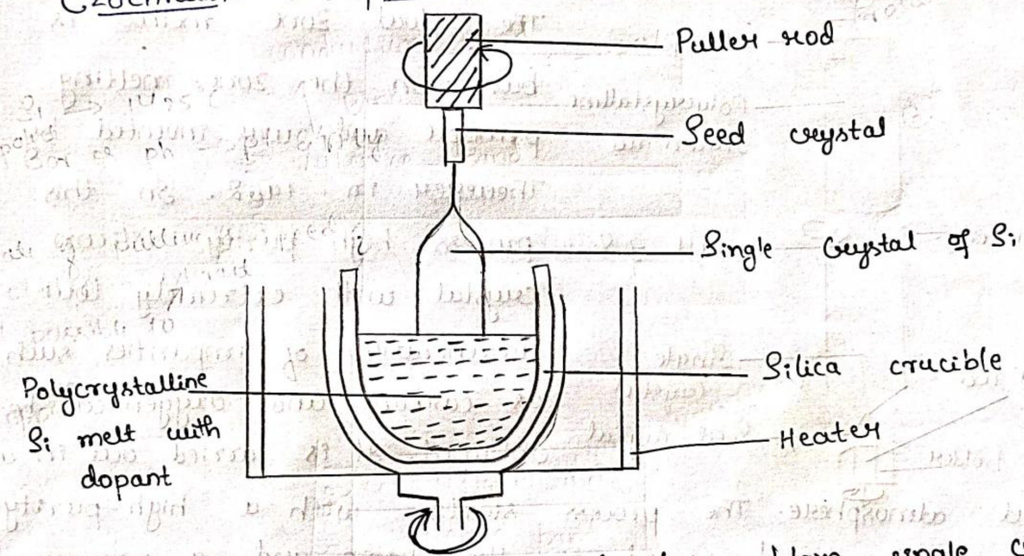
ex:- wood. glass, quartz,. plastic etc.



Prepration of Single Crystal Silicon :

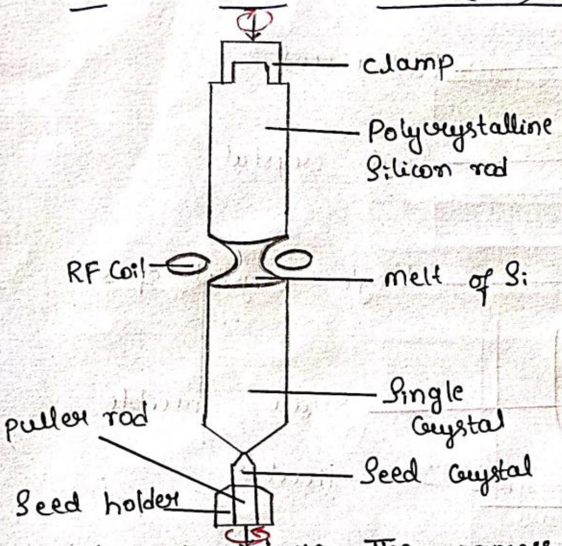
Silicon is obtained by process called polycrystalline. But for the fabrication of semiconductor device, Silicon should by single crystal. There are two methods are used to obtain Single crystal - Czochralski and float zone method.

Czochralski (CZ) process :



Czochralski method is used to obtain single crystals of Semiconductors like Silicon. ~~and~~ High- purity, Semiconductor- grade silicon is melted in a quartz crucible at 1425°C using RF coil. Dopant such as boron or phosphorous can be added to the molten silicon. in precise amount to obtain P-type and ~~n~~-type silicon. A monocrystalline seed crystal fixed to the puller rod is rotated slowly at the rate of 50 rpm and dipped into the melt. Then the rod is slowly pulled upwards at the rate of 1.5 to 5cm per hour and rotated simultaneously. By precisely controlling the temperature, rate of pott pulling and speed of rotation, it is possible to extract a large, single-crystal of silicon from the melt. This process is normally performed in an inert atmosphere, such as argon.

The Float Zone (FZ) method :



The float zone method is based on the zone-melting principle and was invented by Theuerer in 1962. In this process high purity silicon crystal with extremely low concentration of impurities such as carbon and oxygen can be obtained. It is carried out in an inert atmosphere. The process starts with a high-purity polycrystalline rod fixed to the clamp and a monocryst-alline seed crystal fixed to the seed holder. They are held face to face in a vertical position and rotated as shown in the figure. Melt the feed rod using radio frequency heating coil and the seed crystal is brought up from below to make contact with a drop of melt formed at the tip of the poly silicon feed rod. The molten ~~zinc~~ is Silicon solidifies into a single crystal and the material is purified simultaneously. The crystals can be doped by

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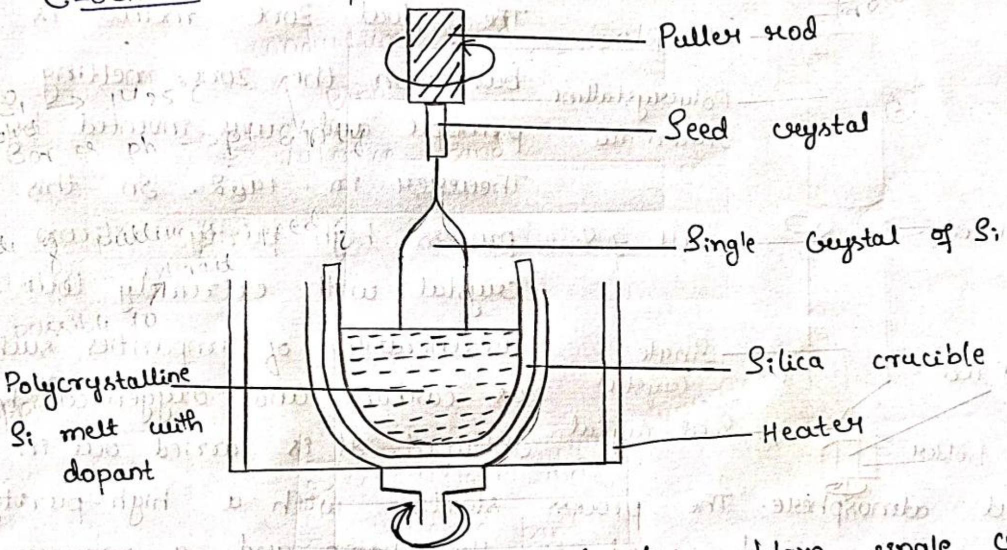

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Polymer.

Polymer are material with large molecular mass obtained by the covalent linkage of several small repeat chemical units called as monomer.

* polymers in greek means poly - many, mers - units or parts
* The monomer units are linked together by covalent linkage
* The properties of polymer are different from the properties of the monomers constituting them.
* Average molecular mass of commercial polymers is normally in the range of $10^3 - 10^7$

ex : polymers → polyethylene, polystyrene, teflon etc.

* Naturally occuring macromolecule is insulin, a protein harmone in the pancreas & lower blood sugar in diabetic patients.

The science of macromaterials is divided b/w biological and non-biological, each having important in our daily.

* Biological polymers :- proteins, nuclic acids (DNA, RNA) starch cellulose, enzymes.

These biological polymers are foundation of life.

* Non-biological polymer / Synthetic polymers :- plastic, fibres, elastomer, rubber, wool.

The name of polymer is derived from the name of the monomers (repeating unit) by prefixing the word poly to

ex : polyethylene - is a polymer of the repeat monomer ethylene.

Molecular weight:

Average molecular weight:

In a polymer soln. all the polymer doesnot get terminated after growing to the same size and hence th have different no of monomer units and thus different molecular weights. A ~~monom~~ polymer sample can.

Therefore, be thought of as a mixture of molecules of same type, but of different molecular weight.

Hence the molecular weight of the polymer sample is expressed as average of the molecular weight contributed by the individual molecule that make the sample.

Number- Average molecular weight ($\overline{M}n$)

Let 'n' be the total number of molecules in polymer sample and n_1 monomer molecules of mass M_1, n_2 monomer molecules of mass M_2 and so on.

∴ The no average molecular weight is given by

Total number of monomer molecules (n) given by

$$n = n_1 + n_2 + n_3 + \ldots\ldots + n_i = \Sigma n_i$$

Number of moles in fraction $i = n_i$

Number fraction of fraction $1 = \frac{n_1}{n} = \frac{n_1}{\Sigma n_i}$

Number fraction of fraction $2 = \frac{n_2}{n} = \frac{n_2}{\Sigma n_i}$

molecular weight contribution by fraction 1 = number fraction × mol. wt

$$= \frac{n_1}{\Sigma n_i} \times M_1$$

$$= M_1 n_1$$

molecular weight contribution by fraction 2 = no fraction × mol. wt

$$= \frac{n_2}{\Sigma n_i} \times M_2$$

$$= \frac{M_2 n_2}{\Sigma n_i}$$

∴ number average molecular weight of the whole polymer will be given by.

$$\bar{M}_n = \frac{n_1 M_1}{\Sigma n_i} + \frac{n_2 M_2}{\Sigma n_i} + \dots\dots\dots + \frac{n_i M_i}{\Sigma n_i} = \frac{\Sigma n_i M_i}{\Sigma n_i}$$

$$\boxed{\bar{M}_n = \frac{\Sigma n_i M_i}{\Sigma n_i}}$$

The number average molecular weight is therefore arithemetic mean of all the molecular weight of the polymer chain in the sample.

Weight average molecular weight ($\bar{M}_w$)

The experiment which yields weight average molecular weight given the contribution of each molecular or chain to the measured results relative to its size.

Total weight of the polymer $W = n_1 M_1 + n_2 M_2 + \dots + n_i m_i = \Sigma n_i m_i$

weight of fraction 1 = $w_1 = n_1 m_1$

weight fraction of fraction 1 = $\frac{n_1 m_1}{W} = \frac{n_1 m_1}{\Sigma n_i m_i}$

weight fraction of fraction 2 = $\frac{n_2 m_2}{W} = \frac{n_2 m_2}{\Sigma n_i m_i}$

molecular weight contribution by fraction 1 =

= wt fraction × molecular weight

$$= \frac{n_1 m_1}{\Sigma n_1 m_1} \times m_1$$

$$= \frac{n_1 m_1^2}{\Sigma n_i m_i}$$

molecular contribution by fraction 2 = wt fraction × mol. wt

$$= \frac{n_2 m_2}{\Sigma n_2 m_2} \times m_2$$

$$= \frac{n_2 m_2^2}{\Sigma n_i m_i}$$

The weight - average molecular weight of the whole polymer is given by $\overline{M}_w = \frac{n_i m_1^2}{\Sigma n_i m_i} + \frac{n_2 m_2^2}{\Sigma n_i + m_i} + \ldots\ldots + \frac{n_i m_i^2}{\Sigma n_i m_i} = \frac{\Sigma n_i m_i^2}{\Sigma n_i m_i}$

$$\overline{M}_w = \frac{\Sigma n_i m_i^2}{\Sigma n_i m_i} \quad \text{or} \quad \overline{M}_w = \frac{\Sigma c_i m_i}{\Sigma c_i}$$

$c_i = \Sigma n_i m_i$ where c_i = conc of polymer soln g/cm^3

Note: for all synthetic polymer $M_w > M_n$

for homogenous $\overline{M}_w = \overline{M}_n$ (which is not possible).

Definition for number- average molecular weight (M_n)

It is the ratio of total mass of all the molecules of a sample to the total number of molecules.

$$\boxed{\overline{M}_n = \frac{\Sigma N_i M_i}{N_i}}$$

Definition for weight - average molecular weight ($\overline{M}_w$)

It is the ratio of products of total mass of groups of molecules to the total mass of all molecules.

$$\boxed{\overline{M}_w = \frac{\Sigma N_i m_i^2}{\Sigma N_i m_i}}$$

Polydispersity Index :

It is the measure of number of molecular species having different, sizes, equal to the ratio of weight average molecular mass to number average molecular mass :

$$PDI = \frac{\overline{M}_w}{\overline{M}_n} \geq 1.$$

higher the value greater the polydispersity.

Numerical problems:

1) A polymer has the following composition 100 molecular mass 1000g/mol, 200 molecular mass 2000g/mol. 500 molecular mass 5000g/mol. Calculate $\overline{M}_n$ & $\overline{M}_w$

given: $m_1 = 1000 \text{ g/mol}$ $\quad N_1 = 100$

$m_2 = 2000 \text{ g/mol}$ $\quad N_2 = 200$

$m_3 = 5000 \text{ g/mol}$ $\quad N_3 = 500$

$$\overline{M}_n = \frac{N_1 m_1 + N_2 m_2 + N_3 m_3}{N_1 + N_2 + N_3}$$

$$= \frac{100 \times 1000 + 200 \times 2000 + 500 \times 5000}{100 + 200 + 500}$$

$$= 3.75 \times 10^3 \text{ g/mol.}$$

$$\overline{M}_w = \frac{N_1 m_1^2 + N_2 m_2^2 + N_3 m_3^3}{N_1 m_1 + N_2 m_2 + N_3 m_3}$$

$$= \frac{100 \times 1000^2 + 200 \times 2000^2 + 500 \times 5000^2}{100 \times 1000 + 200 \times 2000 + 500 \times 5000}$$

$$= 4.46 \times 10^3 \text{ g/mol}$$

2. A polymer of polyethylene is found to contain

a) $R\{CH_2-CH_2\}_{400}R$ 10%.

[atomic mass of C = 12]
[atomic mass of H = 1]

b) $R\{CH_2-CH_2\}_{550}R$ 40%.

c) $R\{CH_2-CH_2\}_{650}R$ 50%.

calculate $\overline{M}_n$ and $\overline{M}_w$

Solution: $a = m_1 = (12\times2+1\times4)400 = 112800$ $n_1 = 10$

$b = m_2 = (12\times2+1\times4)550 = 15400$ $n_2 = 40$

$c = m_3 = (12\times2+1\times4)650 = 18200$ $n_3 = 50$

$$\overline{M}_n = \frac{m_1N_1 + m_2N_2 + m_3N_3}{N_1+N_2+N_3}$$

$$= \frac{11200\times10 + 15400\times40 + 18200+50}{10+40+50}$$

$= 16380$ g/mol

$$\overline{M}_w = \frac{N_1m_1^2 + N_2m_2^2 + N_3m_3^3}{N_1m_1 + N_2m_2 + N_3m_3}$$

$$= \frac{10\times11200^2 + 40\times15400^2 + 50\times18200^2}{10\times11200 + 40\times15400 + 50\times18200}$$

$= 16668.37$ g/mol

In a polymer sample, 20% of molecules have molecular mass 12000 g/mol. 30% of molecules have molecular mass 20000 g/mol. remaining molecules have molecular mass 22000 g/mol. calculate the number average molecular mass, weight average molecular mass of polymer and PDI

Solution: given.

$N_1 = 20, \quad m_1 = 12000$ g/mol

$N_2 = 30, \quad m_2 = 20000$ g/mol

$N_3 = 50, \quad m_3 = 22000$ g/mol

$$\bar{m}_n = \frac{N_1 m_1 + N_2 m_2 + N_3 m_3}{N_1 + N_2 + N_3}$$

$$= \frac{(20 \times 12000) + (30 \times 20000) + (50 \times 22000)}{20 + 30 + 50}$$

$= 19400$ g/mol.

$$\bar{m}_w = \frac{20 \times (12000)^2 + 30 \times (20000)^2 + 50 \times (22000)^2}{(20 \times 12000) + (30 \times 20000) + (50 \times 22000)}$$

$= 20144$ g/mol

$$PDI = \frac{m_w}{m_n}$$

$$= \frac{20144}{19400}$$

$= 1.03835$ g/mol.

Conducting polymers :

Organic polymer that has delocalized pi electrons in their back bone and conduct electricity are called conducting polymers.

In polymer, electrons are localized and do not take part in conduction and also there are wide energy gap between VB and CB. This makes polymer exhibit poor conductivity. But doping can delocalize the electrons responsible for conduction.

The insulating polymer with conjugated backbone contain alternative double and single carbon - carbon bands are converted into a conductor by doping it with electron acceptor such as I_2, $FeCl_3$ or an electron donor like Sodium naphthalide or protonating agent like HCl.

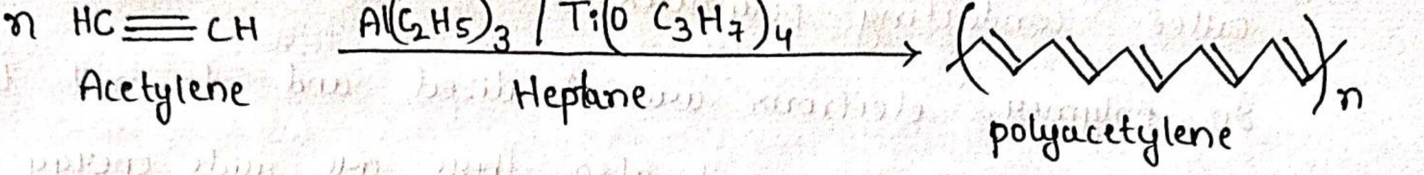
i) Oxidative dopant take away el-n from the π - backbone of polymer and creates holes resulting in the increase of conductivity of polymer ex: polyacetylene.

ii) Reductive dopant donates electrons to π - backbone of the polymer. These electrons are free to move along c-chain resulting in increase conductivity of polymer ex: polyacetylene.

iii) Protonating agent create positive and negative charge in the polymer chain, resulting in increase conductivity ex :- polyaniline.

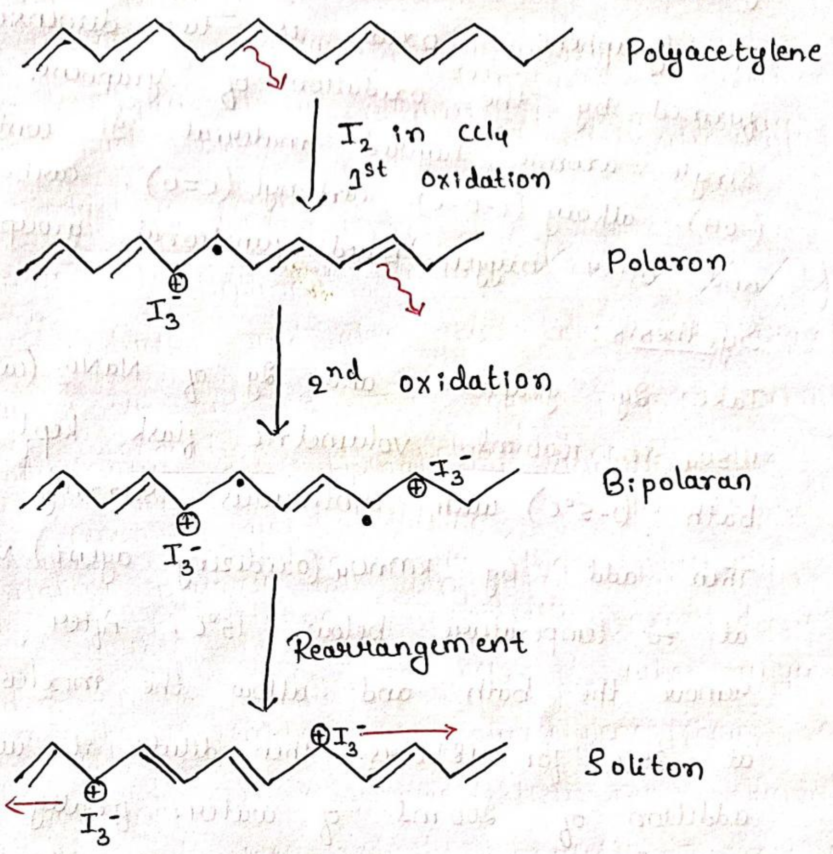
Polyacetylene :

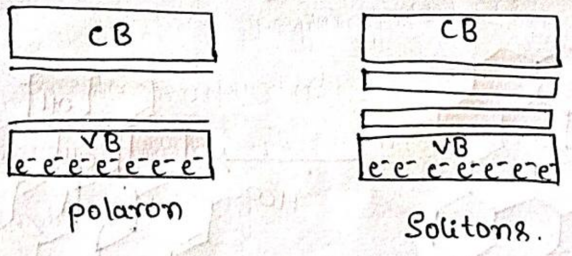
Synthesis : Acetylene undergoes polymerisation in the presence of Ziegler - Natta catalyst to form polyacetylene.



Mechanism of Conduction in polyacetylene :

The conductivity of polyacetylene is 4.4×10^{-3} S/m. But the doped polyacetylene shows the conductivity of 4×10^{4} S/m. when polyacetylene is partially oxidized with an oxidative dopant like I_2 in CCl_4. it takes away an electron from the π - backbone of polyacetylene chain producing a free radical and positive charge (hole). This combination of charge site and free radical is called polaron. This would create new localized electronic ~~site~~ state in the energy gap. On further oxidation, a bipolaron is formed. If the polyacetylene chain is heavily oxidized. polarons condense pair- wise to form Solitons. which ~~migrat~~ merge with the edge of CB and VB exhibiting conductivity.


Polyacetylene
I2 in CCl4
1st oxidation
Polaron
I3-
2nd oxidation
Bipolaran
Rearrangement
Soliton

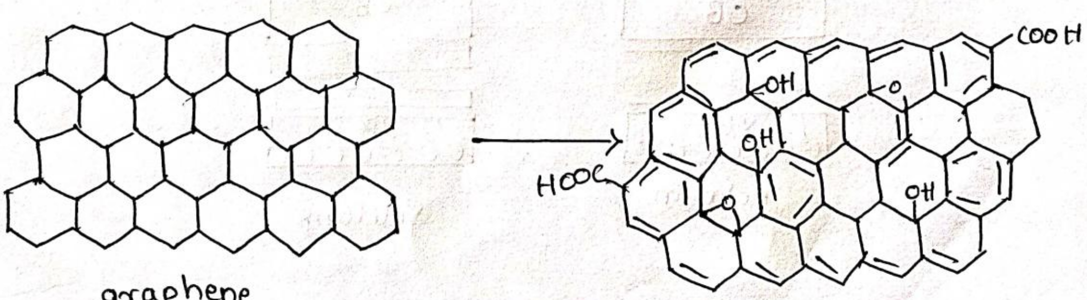

CB
VB
e- e- e- e- e- e- e-
polaron
CB
VB
e- e- e- e- e- e- e-
Solitons.

Graphene Oxide : (GO)

Graphene oxide is two-dimensional material formed by the oxidation of graphene. It is a single atomic layered material. It contain hydroxyl (-OH), alkoxy (C-O-C), carbonyl (C=O), carboxylic acid (-COOH) and other oxygen-based functional groups.

Synthesis:

Take 2g graphene and 2g of $NaNO_3$ (catalyst) in 50ml H_2SO_4 in 1000 ml volumetric flask kept in an ice bath (0-5°C) with continuous stirring for 2 hours. Then add 6g $KMnO_4$ (oxidizing agent) very slowly at ~~ro~~ temperature below 15°C. After some time, remove the bath and allow the mixture for stirring at 35°C for 48 hours. Then dilute it with slow addition of 200 ml of water. finally treat the solution with 10ml H_2O_2 to terminate the reaction and filter. After filtration, dry it in vaccum at room temperature to get powdered graphene oxide.



graphene → graphene oxide

Properties

* It is hydrophilic due to the presence of hydroxyl, alkoxy, carbonyl, carboxylic acid group.
* It can mix with matrix such as polymer and ceramic to improve their mechanical and electrical properties.
* It is hygroscopic and forms a strong hydrogen bond with water molecules.
* It has large Surface area, so it is more reactive
* It has low thermal conductivity and electrical conductivity than graphene.

Applications :

* GO can be used in coating technology.
* It is used in biomedical fields such as drug delivery, cancer therapy, bio-imagining and biosensor.
* Nanocomposite of GO and Silver (Ag) ions used for bacteria detection.
* It is used as bio-imaging tool for cancer cells.
* Reduced GO can be used as energy storage material in supercapacitors and in lithium-ion battery
* Reduced GO that can be produced from GO is used as a transparent electrode in polymer solar cells and LED.

* 2g graphene + 2g $NaNO_3$ in 50ml H_2SO_4 → 1000ml V_f → ice bath 2hr.
* 6g $KMnO_4$ (ox. ag). >15°C.
* mixture for stirrer for ... than 35°C — 48 hr.
* dilute 200 ml H_2O
* 10ml H_2O_2 → to terminate reaction & filter / dry at room temp powdered GO

METAL FINISHING:

Metal finishing is the process of modification of surface properties of a material by coating a thin layer of metal or metal oxide or polymer. Material may be a metal or alloy or composite etc

Electroplating:

Electroplating is the process of deposition of metal on the Surface of another metal by electrolysis.

Electroless plating of copper: To prepare double sided printed circuit boards (PCBs)

The Surface of the article to be subjected to electroless plating is cleaned thoroughly to remove the impurities. ~~Induct~~ Insulators such as plastics, glass and quartz, are activated by dipped first in stannous chloride ($SnCl_2$) in presence of HCl at 25°C and then in palladium chloride ($PdCl_2$). Then the electroless plating is done under the following conditions.

Plating bath composition:

metal salt solution : $CuSO_4$ solution (12g/L)

Reducing agent : Formaldehyde (8g/L)

Complexing agent & Exultant : EDTA (20g/L)

Buffer : NaOH (15g/L) + Rochelle salt (14g/L)

pH : 11

Temperature : 25°C

Reactions :

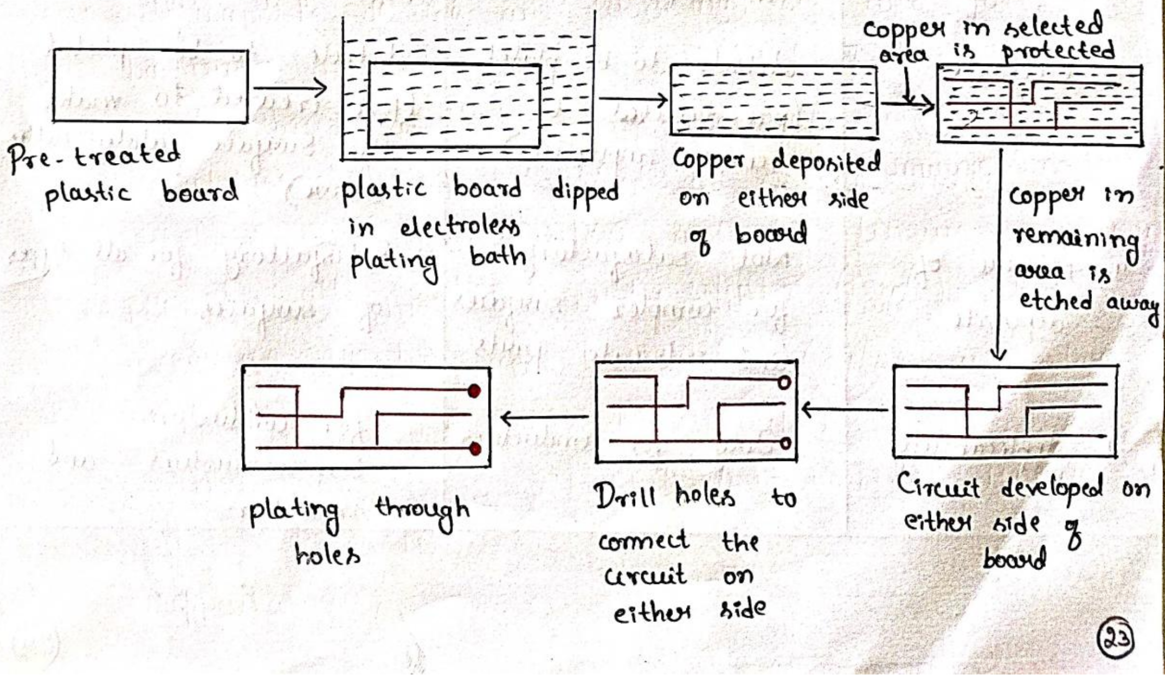
At cathode $Cu^{2+} + 2e^- \longrightarrow Cu$

At anode $2HCHO + 4OH^- \longrightarrow 2HCOO^- + 2H_2O + H_2 + 2e^-$

Net reaction $Cu^{2+} + 2HCHO + 4OH^- \longrightarrow Cu + 2HCOO^- + 2H_2O + H_2$

Process :

Activated plastic board on which circuit to be drawn is dipped in the electroless plating bath solution. Two sides of the plastic board is get coated with copper. Selected areas are protected and the copper in remaining area is etched away. Thus circuits are produced on either sides of the board. The connection between circuits of two sides is made by drilling hole followed by plating through-holes. The steps-involved are shown below.



Technological importance of metal finishing.

1) To get a decorative surface
ex: gold plating on copper.

2) To prevent corrosion. Example: Zinc coating on iron.

3) To modify the surface properties such as thermal resistance, hardness, brightness, brittleness
ex: Chromium or nickel coating on iron.

4) To get thermal and electrical conductivity.

5) Manufacture of electronic components.
Ex: PCB circuits.

Difference between.

Property	Electroplating	Electroless plating.
1. Driving force	power Supply	Autocatalytic redox reaction
2. Anode	Separate anode is required	Separate anode is not required
3. Cathode	Article to be plated (pre-treated to remove impurities)	Article to be plated (Pre-treated to make the Surface catalytically active)
4. Nature of deposite	Not satisfactory for complex surfaces and intricate parts	Satisfactory for all types of surfaces
5. Applicability	Only for conductors	for, conductors, Semiconductors and insulators.

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Nano Materials and Display System:

Nanomaterials:

The materials having at least one dimension in the nano scale range of 1-100 nm are called as nanomaterials.

Size dependent properties of Nanomaterials:

Nanomaterials exhibits several size dependent properties

i) Surface area:

Many physical and chemical properties of a material depend on its surface properties. If a bulk material is subdivided into individual nanomaterials, the total volume remains the same, but the collective surface area is collectively increased.

Thus Surface area is enormously increased on moving from bulk to nanoscale.

ex:- The collective surface area of cube is $6m^2$. If this cube is cut into smaller cube, the surface area will increased to 6000 km^2.

Properties like catalytic activity, gas adsorption, and chemical reactivity depends on the surface area, therefore, nanomaterial can show specific related properties that are not observed in bulk materials.

ex: Bulk gold is catalytically inactive, but gold nanoparticle are catalytically very active for selective redox reaction.

2) Conducting / Electrical properties :

The electrical bands in bulk materials are continuous due to overlapping of orbitals. of billions of atoms. but in nanoparticles very few amount of atoms or molecules are present so the electric bands become separate (discreate). and the separation between different electric state varies with the size of nanomaterials. Hence some metals which are good conductor in bulk become semiconductors and insulators are their size in decreased to nanolevels.

ex :- Silicone nanoparticles.

3) Catalytic properties :

* The catalytic property of materials depends on particle size.
* If the size of the particles reduces from bulk to nanoscale, surface area increases, that leads to very high catalytic activity of the same materials.

ex : Bulk gold is catalytically inactive, but gold nanoparticles are catalytically very active for selective redox reaction.

2) Conducting / Electrical properties:

The electrical bands in bulk materials are continuous due to overlopping of orbitals. of billions of atoms. but in nanoparticles very few amount of atoms or moleculer are present so the electric bands become separate (discreate). and the separation between different electric state varies with the size of nanomaterials. Hence some metals which are good conductor in bulk become semiconductors and insulators are their size in decreased to nanolevels.

ex:- Silicone nanoparticles.

3) Catalytic properties:

* The catalytic property of materials depends on particle size.
* If the size of the particles reduces from bulk to nanoscale, surface area increases, that leads to very high catalytic activity of the same materials.

ex: Bulk gold is catalytically inactive, but gold nanoparticles are catalytically very active for selective redox reaction.

5) Heat treatment : Solid mass (xerogel) obtained is dried at nearly to 800°c to get fine nanoparticle powder.

Advantages :

* Nano materials of high purity with good homogeneity can be obtained.
* Samples can be prepared at low temperature.
* Easy to control the synthesis parameter like shape & size of resulting materials.

2) Precipitation method :

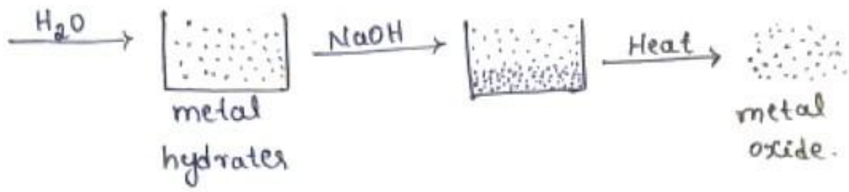
Principle : The principle involves in the precipitation of precursor materials at constant pH via condensation.

Process : In this method inorganic metal salt such as chloride, Sulphate, nitrate ions etc are used as precursor. Precursor materials is dissolved in water and undergo hydrolysis where metal ions exist in metal hydrates form. On adding base like $NaOH/NH_4OH$. pH of the ions changes and reaches super saturation level leading to condensation of precursor to form metal hydroxide precipitate. The precipitate is washed with water, filtered and finally calcinated at higher temperature to convert metal hydroxide into metal oxide by dehydrogenation takes place.

$$mL_x + xH_2O \longrightarrow m(H_2O)_x + xL^-$$

$$m(H_2O)_x \xrightarrow{NaOH} m(OH)_x$$

metal insolube salt



DISPLAY SYSTEMS :

Display System is a system through which we can visualise.

LIQUID CRYSTALS :

A distinct state of a matter in which degree of molecular ordering is intermediate between the ordered crystalline state and completely disordered liquid state

(or)

Liquid crystal is a state of matter whose properties are between those of liquids and those of solid crystals. for ex: a liquid crystal may flow like a liquid but its molecules may be oriented in a crystal-like way.

Classification of liquid crystals :

Liquid crystals is classified as follows

1) Thermotropic liquid crystals.

2) Lyotropic liquid crystals.

Thermotropic liquid crystals :

The compounds which exhibit liquid crystal behaviour with variation of temperature are called as thermotropic liquid crystals.

ex: p-cholesteryl benzoate (Solid) $\xrightarrow{145^\circ C}$ p-cholesteryl benzoate (liquid crystal)

Lyotropic liquid crystals :

Some of the compounds transformed into liquid crystal phase when mixed with another substance or solvent by the variation of concentration of compound are called lyotropic liquid crystals.

ex : Soap water mixture
phospholipid water mixture.

- liquid crystal
  - Thermotropic LC
    - Rod like
      - nematic LC
      - Smectic LC
    - Disc like — columnar LC
  - Lyotropic LC
    - Lameller
    - Hexagonal
    - Cubic

Thermotropic liquid crystals are classified into 4-types

1) Nematic LC or Thread-like LC :

* These are formed by the compounds that are optically inactive
* The molecules have elongated shape and are oriented parallel to the direction.

ex: p-azoxyphenetole.

2) Chiral liquid crystal or Cholesteric LC :

* These are formed by optically active compounds having chiral center.
* Hence molecules acquires spontaneous twist about an axis normal to molecular direction.

The director is not fixed in position but rotates throughout the sample in helical pattern

3) Smectic LC or Soap-like LC :

* The molecules in smectic crystals are oriented parallel to each other as in the nematic phase but in layers.
* Based on the orientation of the director there are many types of smectic phases such as A, B, C, etc.
* If the director is perpendicular to the plane, it is called smectic LC. The molecules are arranged in column.

4) Columnar LC :

* In these LC, there is an orientation order but no positional order.
* There is a random motion of the molecules perpendicular to the plane.

Properties of LC :

* They exhibit optical anisotropy.
* The intermolecular forces are rather weak and can be perturbed by an applied electric field.
* polar molecules interact with an electric field. which causes them to change their orientation slightly.
* LC can flow like a liquid, due to loss of positional order.
* optically birefringent due to its orientation order.
* Exhibits thermal expansion like other matters

Applications of LC:

LCD are used in

* LCD T.V.
* Computer monitors
* Instrument panel
* Indoor and outdoor signage
* Speedometer.
* LCD projectors
* Digital camera, Digital thermometer, Digital equipments.
* watch.
* Calculator
* Smart phones. or mobile phones

used in humidity sensing, chemical sensing

Organic light Emitting Diodes (OLED'S)

An OLED is the light emitting diode in which electro-luminiscent layer is a thin film of organic compounds. that emits light in response to electric current applied.

Properties of OLED:

* OLED devices have solid and planar structure. therefore, OLED panels are verythin, flat and lightweight.
* OLED devices have - self emission property and hence their devices have high contrast ratio and wide viewing angles.

* They response time of OLED is as fast as micro and nanoseconds order. Therefore OLED displays can produce sharpe moving image.
* In OLED, the emission is ~~formed~~ from organic materials. using variation of different organic materials various colours can be generated. Therefore full - colour image can be created.
* The driving voltage of OLED devices is low, just a few volts. Therefore OLEDs can be drive by thin film transistors (TFT). Hence power consumption of OLED display is very low.
* Due to use of TFT, high information content is possible with OLED display.

Applications of OLED:

OLED are used in

* T.V. and display
* laptop
* mobile phone or cellular phones
* camera display systems
* These are also used in lightings.
* wearable devices
* automobiles
* medical field
* Driver information center
*

Nanofiber:

Nanofibers are fibers with diameter in the range of 1-100 nanometers.

Properties of nanofiber:

* Have excellent mechanical properties
* Have satisfactory biodegradability
* Provide higher Surface area
* Have roughness and abrasion resistance
* Have light weight

Application:

* Carbon nanotubes are used as gas sensors to detect H_2S. NH_3. NO_2, CO, CH_4, H_2 & ethanol
* Used in electrical and thermal conductivity applications
* Used in drug delivery applications.
* Used in cosmetic skin masks
* military protector, clothing, tissue engineering.

Nanosensors :

Properties

* Optical sensors measures change in light intensity
* Electrochemical nanosensors measures change in electric distribution
* Piezoelectric nanosensors measures change in mass
* Calorimetric nanosensors measures change in heat

Applications

* To detect various chemicals in gases for pollution monitering
* For medical diagnostic purposes
* To monitor physical parameters like temperature, displacement and flow
* To monitor plant signaling and metabolism to understant pland biology
* To study neurotransmitters in brain to understant neurophysiology.

Perovskite Materials: ($CaTiO_3$)

Pervovskite materials are calcium titanium oxide mineral composed of calcium titanate ($CaTiO_3$) which are low cost energy materials used in various optoelectronic & photonic devices.

Properties:

* High absorption coefficient
* Long range ambipolar charge transport
* Low exciton - bonding energy
* High dielectric constant
* ferroelectric property

Applications

* Used for the preparation of SOFC electrolyte/ electrode
* Used as sensor to sense hydrogen
* Used for the production of Hydrogen
* Used as piezoelectric transduser | Thermistor
* Used as catalyst. Thin film ~~sensor~~ resistor laser
* Superconductor, magnetic memory. ferromagnetic.