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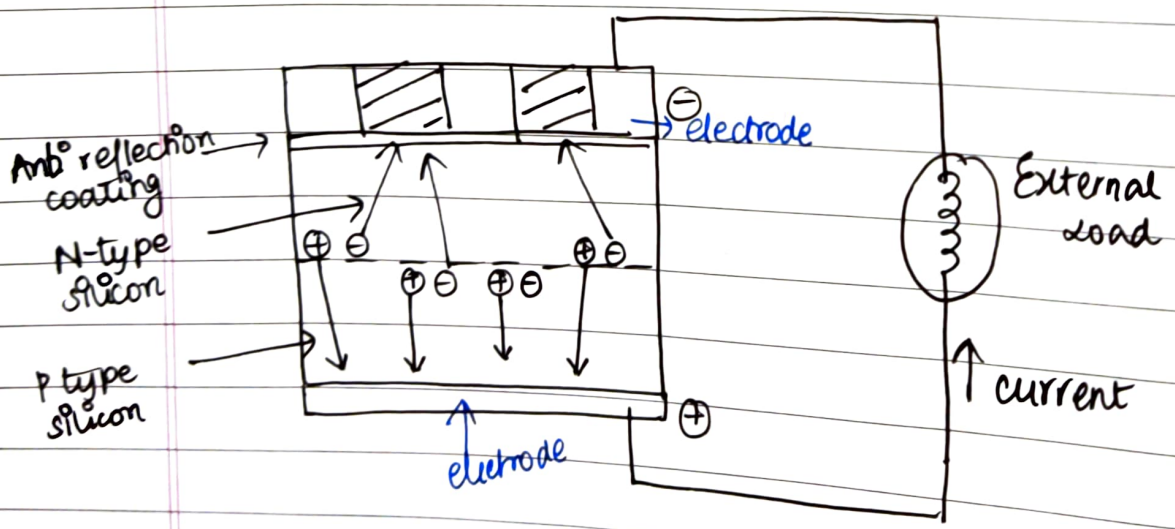
SOLAR CELL

→ A solar cell is an electrical device that converts energy directly into electricity via photovoltaic effect.

→ It is also known as photovoltaic cell.

Types of Solar Cell

- Photovoltaic cell
- Photoelectrochemical cell
- Dye-sensitized solar cells Light cells



Photovoltaic cell

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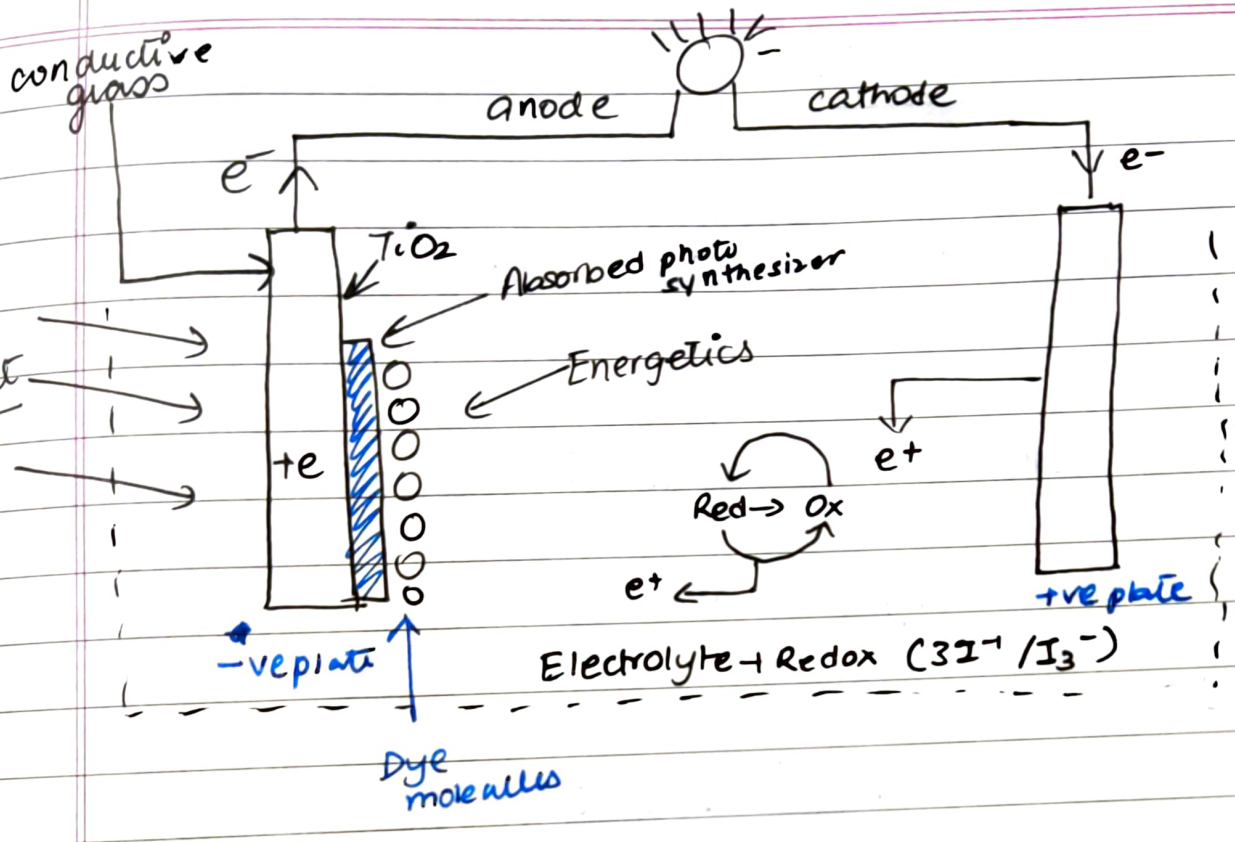
Dye sensitization
Gratzel cell

- Sunlight energy (photon) passes through Titanium dioxide layer and strikes electrons within absorbed dye molecules.
- e^- gain this energy → excited because they have the extra energy.
- excited e^- escape the dye molecule and become free ~~molecules~~. electrons.
- These free e^- move through the titanium dioxide and accumulate at the (-ve) plate (dyed TiO_2 plate)
- The free e^- move in the circuit now and powers the bulb.
- dye regeneration → gets back its electrons from Iodide electrolyte
  Iodide (I^-) ions are oxidised (loss of 2 e^-).
  The free electrons on graphite plate then reduce the tri-iodide molecules.


conductive glass
anode
cathode
e⁻
e-
TiO2
Absorbed photo synthesizer
Energetics
light
+e
e+
Red → Ox
e+
+ve plate
-ve plate
Electrolyte + Redox (3I⁻ / I3⁻)
Dye molecules

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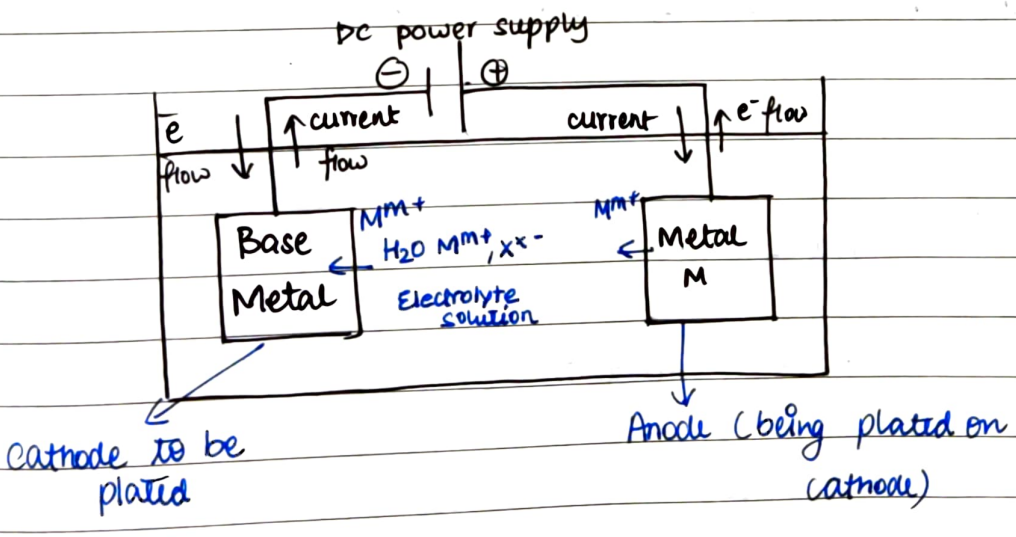
Electroplating →

→ Process in which DC electric current through an electrolytic solution contain soluble salt of coating metal ions so that they form a thin metal or alloy layer coating over another metal. (as cathode).

→ The term is also used for electrical oxidation of anions onto a solid substrate, as in formation silver chloride on silver wire to make silver / silver-chloride electrodes.

→ The process used in electroplating is called electrode position It is analogous to a galvanic cell acting in reverse. The part to be plated is the cathode of the cathode.



Electroplating metal M on metal Z

Example →

Electroplating of copper

→ Base metal treated with dil HCl to remove oxide layers

→ Anode & Copper foil
→ Cathode : Object to be coated
→ Electrolyte : copper sulphate

Reactions →

Anode :- $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
Cathode :- $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

Objectives →

→ decorative appearence
→ Improved thermal resistance
→ Improved corossion resistance
→ Improved chemical resistance

Fuel Cells →

Electrical energy is obtained without combustion from oxygen & gas that combustion from oxygen & gas that can be oxidized. Thus a fuel cell converts chemical energy of fuels directly to electricity.

Fuel + Oxygen → Oxidation products + Electricity

example →

H_2-O_2 fuel cell

Reactions

Anode : $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$

Cathode : $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Net reaction : $2H_2 + O_2 \rightarrow 2H_2O$

→ H_2 (through anode) & O_2 (through cathode) gases are bubbled through respective compartments

→ Electrode – porous, good conducting, excellect catalyst for reaction that take place on their surfaces, not deteriorating by electrolyte that (or) electrode reaction.

Graphite impregnated with finely divided platinium (or) alloy of Pd, Ag & Ni sires the purpose of hydrogen is the fuel.

electrolyte :- aqueous KOH (or) H_2SO_4

Some major types of fuel cells or :

1. Hydrogen Oxygen Fuel Cell (HOFC)
2. PEMFCs (Proton exchange (or) polymer electrolyte membrane)
3. AFCs (Alkaline)
4. PAFCs
5. MCFCs
6. SOFCs
7. DMFCs
8. DAFCs
9. DCFCs

Fuel Cells

Alkaline Fuel Cells (AFC)

* consumes hydrogen, water, producing pure water, heat & electricity.

Anode & cathode → inert and porous graphite electrode impregnated with finely divided platinum catalyst (or) alloy of [Pd, Ag and Ni] serves the purpose if hydrogen is the fuel

Hydrogen (through anode) and O_2 from (cathode) are bubbled through the respective compartments.

electrolyte: 25% of KOH (soln).

Hydroxyl ions (OH^-) migrate from the cathode to anode

At the anode, hydrogen gas reacts with the $OH^\ominus$ ions to produce water and release electrons

Released $e^\ominus$ supply electrical power to an external circuit the return to the cathode where it reats with O_2 and water

to give more hydroxyl ions.

At anode : $2H_2(g) + 4(OH^-)(aq) \rightarrow 4H_2O(l) + 4e^\ominus$

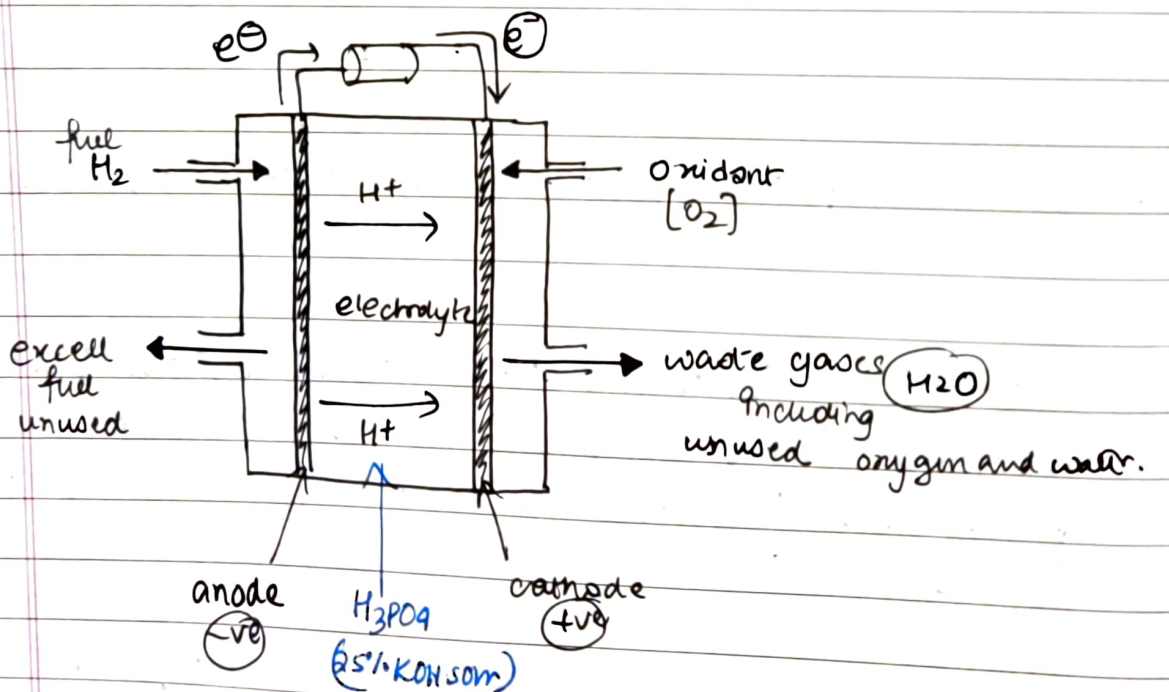
$E_{anode}^\circ = -0.83\ V$

At cathode : $O_2(g) + 2H_2O(l) + 4e^- \rightarrow OH^-(aq)$

$E_{cathode}^\circ = 0.40\ V$

net reaction : $O_2(g) + 2H_2(g) \rightarrow 2H_2O(l)$.

$E_{cell} = 1.23\ V$



Proton exchange Membrane Fuel Cell (PEMFC)

- This type of fuel cell is utilized water-based, acidic polymer electrolyte membranes (PEMs) such as Nafion to conduct protons for ion exchange purpose.
- PEMFC cells operate at relatively low temperature (<80°C)
- Due to the relatively low temperatures and use of precious metal-based electrodes, these cells must operate on pure hydrogen

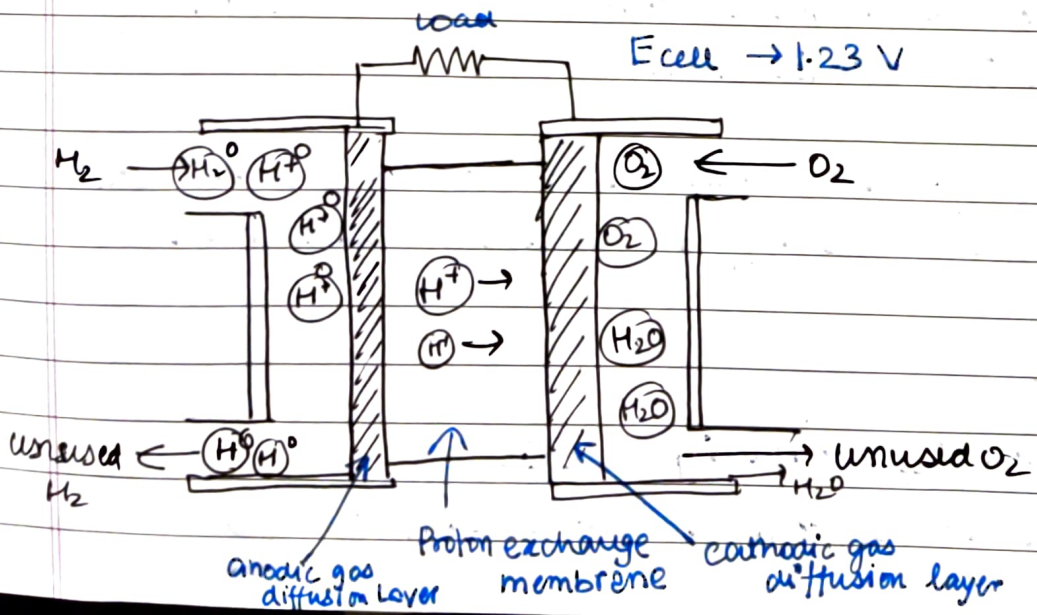
- Hydrogen are fuel is processed at the node where electrons are seperated from protons on the surface of a platinum based catalyst.

- The protons pass through the membrane to the cathode side of the while the electrons travel in an external circuit, generating the electrical output of the cell.

Anode $H_2(g) \rightarrow 2H^{\oplus} + 2e^{\ominus}$

Cathode $O_2(g) + 4H^{\oplus} + 4e^{\ominus} \rightarrow 2H_2O$

net $O_2(g) + 2H_2(g) \rightarrow 2H_2O(l)$



SOFC [Solid oxide fuel cell] (ceramic FC)

* High temperature FC, that utilizes solid ceramic inorganic oxide as an electrolyte

→ Zirconium oxide stabilized with Yttrium oxide instead of a liquid membrane. YSZ (Yttria - stabilized Zirconia

→ H_2 and CO are used as fuel.
→ High temperature 800°C - 1000°C

efficiency over 60% when converting fuel to electricity.

Anode (or) fuel electrode →

"Nickel mixed with YSZ" called "nickel YSZ cermet"
It is a porous ceramic layer to allow the fuel to flow towards electrolyte.

Cathode (or) air electrode →

* The cathode is a mixed ion-conducting and electronically conducting ceremic material

* It is a thin porous ceramic layer coated over the solid electrolyte where oxygen reduction takes place

Electrolyte →

Oxide ion (O_2^-) conducting ceremic
most popular electrolyte → (YSZ layer + Gadolinium doped CeO_2)

At anode (oxidation)

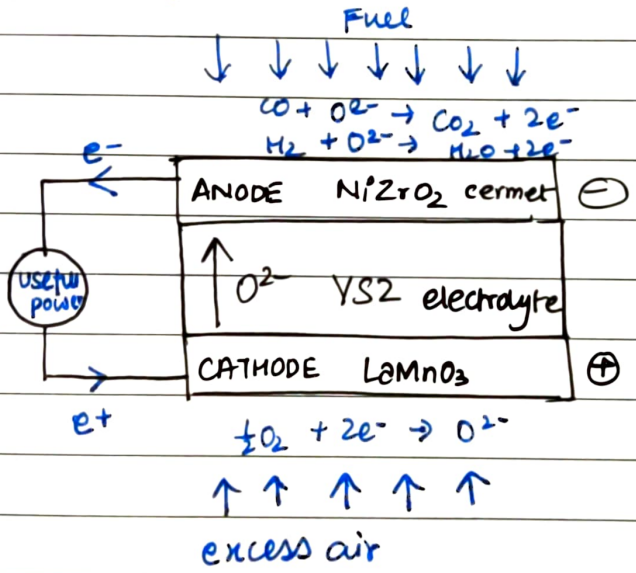
$H_2(g) + CO(g) + 2O^{2-} \rightarrow H_2O(g) + CO_2(g) + 4e^{\ominus}$

At cathode (reduction)

$O_2(g) + 4e^- \rightarrow 2O^{2-}$

Net reaction →

$H_2(g) + CO(g) + O_2(g) \rightarrow H_2O(g) + CO_2(g)$



Lithium Ion Battery →

→ Lithium ion batteries are called secondary batteries

→ The battery consists of anode as, Lithium, dissolved as ions, into carbons.

→ The cathode material is made up from Lithium liberating compounds, typically the three electro-active oxide materials:

① Lithium Cobalt Oxide ($LiCoO_2$)
② Lithium Manganese-oxide ($LiMn_2O_4$)
③ Lithium Nickel-oxide ($LiNiO_2$)

→ The anode is carbon based with composition $Li_{0.5}C_6$

→ Lithium content is lower than would ideal, however higher capacity carbons pose safety issues.

continued → secondary battery →

Lithium solid battery ($LiMnO_2$)

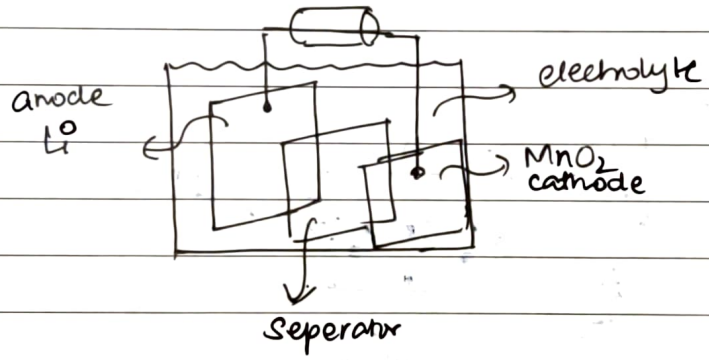
Lithium manganese dioxide cell →

* Electrolyte in this cell is a solid electrolyte. The most widely used cell in lithium-manganese cell (3V). MnO_2 heated to 300°C to remove water before keeping it in the cathode, thereby increasing the efficiency of the cell.

At anode → $Li \rightarrow Li^+ + e^\ominus$

At cathode → $e^- + MnO_2 \rightarrow MnO_2^\ominus$

Net Reaction → $Li + MnO_2 \rightarrow LiMnO_2$



* coin type cells.

Secondry Lithium Ion Battery →

* The charging and discharging takes place with the movement of lithium ions

Cathode: Layers of lithium-metal oxide $\underset{LCO}{LiCoO_2}$, $LiNiO_2$ & $\underset{LMO}{LiMn_2O_4}$)

Anode: Layers of porous carbon (graphite, usually with composition $[Li_{0.5}C_6]$.

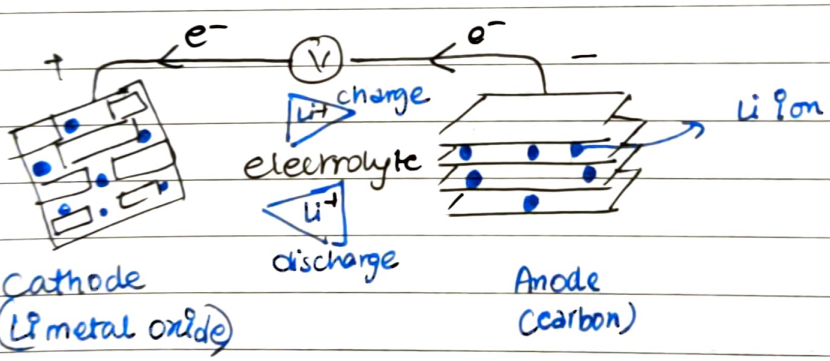
Electrolyte: polymer gel

How it works?

Lithium-ion uses a cathode (positive electrode), an anode (-ve electrode) and an electrolyte.

The cathode is a metal oxide and anode consists porous ~~metal~~ carbon.

During discharge the ion flows from anode to cathode through the electrolyte and seperator.
Charge reverses the direction and ion flows from cathode to anode.



Discharge →
The Li^+ ions flow back from the negative electrode to the positive electrode through the electrolide. The electrons flow from the negative electrode to the +vee electrode.

(*) The Li ions and electrons combine at the positive electrode and deposit there as Li

$$Li_{1-x}CO\ O_2 + CLi_x \rightarrow LiCOO_2 + C$$

Charging Reaction →

- Li^+ ions flow from the +ve electrode ($LiCoO_2$) to the negative electrode (graphite) (porous carbon) through electrolyte.

The e^- also flow from +ve electrode to -ve electrode. The electrons & Li^+ combine at the anode and deposit there as (Li).

$$LiCoO_2 + C \longrightarrow Li_{1-x}CoO_2 + \underbrace{CLi_x}_{\text{deposited.}}$$

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Conducting Polymers

A conducting polymer is an organic based polymer that can be acts as an semiconductor (or) a conductor.

→ Most widely studied organic polymers are Polyacetylene, polyaniline, (PANI) polypyroles, polythiophenes, polyphenylene vinylenes.

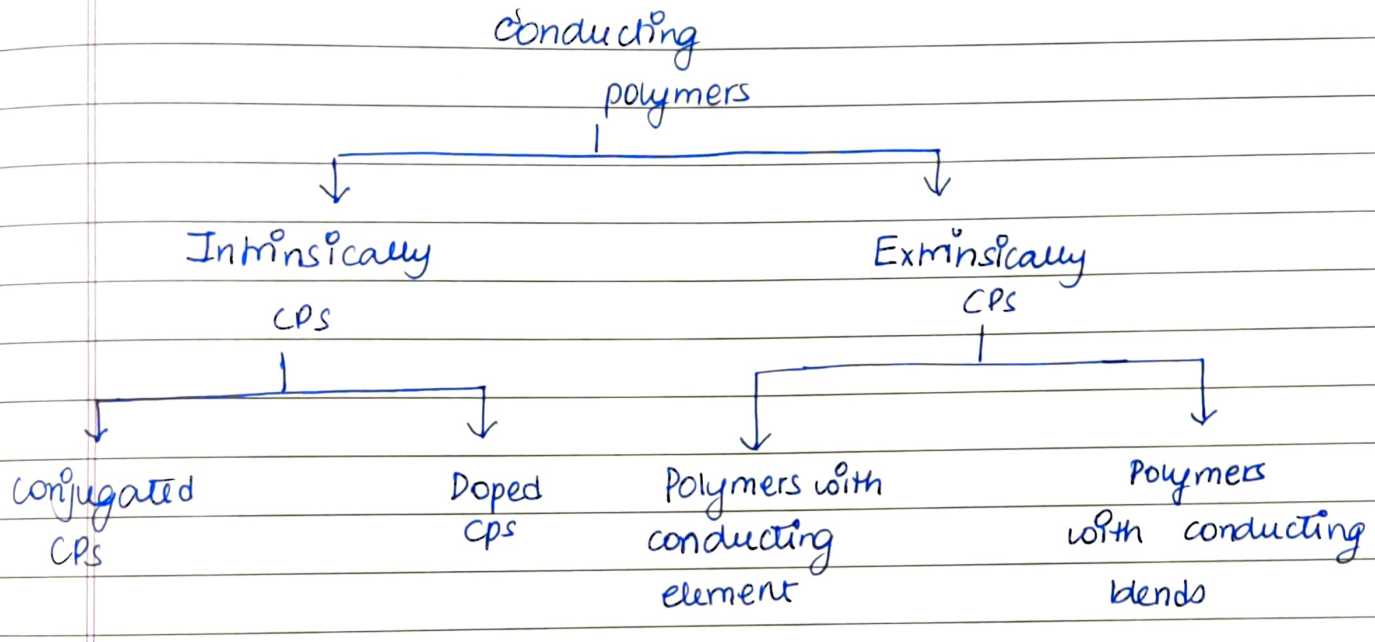
→ Conducting polymers (CPs) are extensively conjugated molecules. They have alternating single & double bonds

In these molecules, e-s are able to more from one end of polymer to other through extended p-orbital system

→ Hence CPs are thrown to be either semiconductors or conductors giving them unique optical & electrical properties.

→ Most polymers are poor conductors due to non-availability of large no. of free e-s in conduction process.

Types of conducting polymers



Factors affecting conductivity →

1. Density of charge carriers
2. The mobility
3. The direction
4. Presence of doping materials
5. Temperature