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Theory Assignment

Engineering Chemistry (CHY1701)

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Slot: G2+TG2

Question

Provide Explanation for the following topics:

1. Solar cells
2. Dye Sensitized solar cells- working principle, characteristics and applications
3. Electroplating
4. Fuel cell
5. Lithium-ion batteries
6. Conducting Polymers

Answer

Solar cells

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Digital Assignment

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Solar cells

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

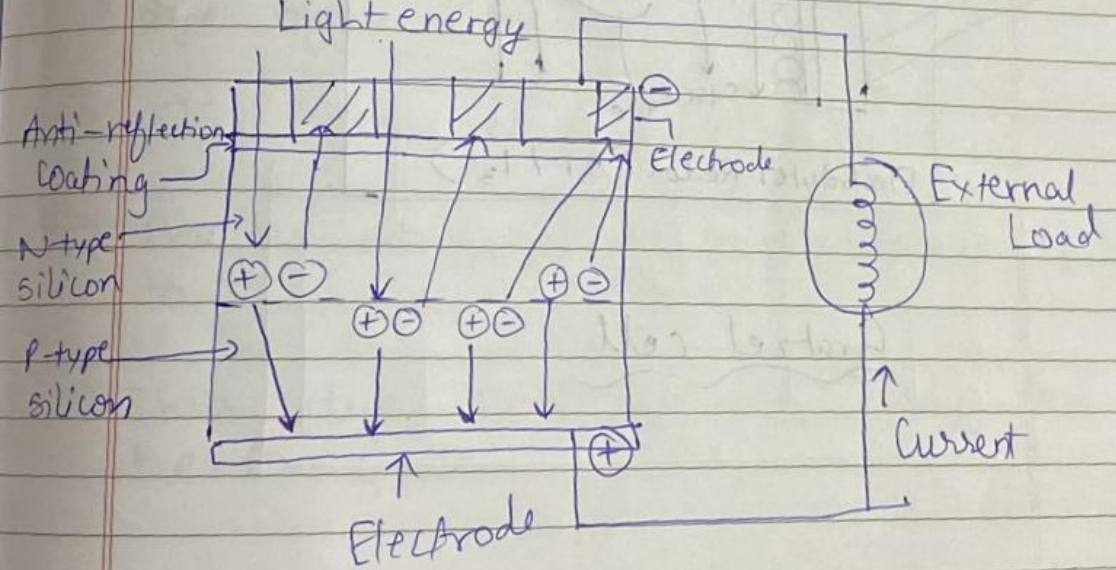
→ It is also known as photovoltaic cell

→ Types of solar cells:-

1) Photovoltaic cells

2) Photoelectrochemical cells

3) Dye-sensitized solar cells



Photovoltaic cell

Dye Sensitized solar cells

→ Photovoltaic cell is used in Aerospace & satellites, etc.

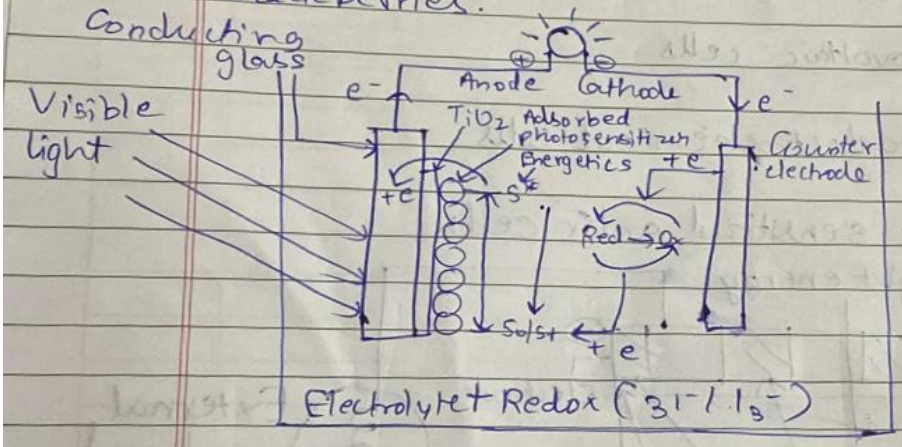
Dye sensitized solar cells

→ A common cell used is called Grätzel cell

→ Utilizes organic dyes

→ Dye examples: - Ruthenium - Polypyridine

→ Dyes are extracted from simple foods like hibiscus tea, tinned summer fruits, blackberries.



Gratzel cell

Working principle of gratzel cell

→ Sunlight passes through TiO_2 layer & strikes e⁻s in dye molecules

→ e⁻s get excited & escape dye molecules to become free e⁻s

→ Free e⁻s move through TiO_2 & accumulate at -ve plate (dyed TiO_2 plate)

→ Free e⁻s move through external circuit to generate electricity & light the bulb.

→ We must regenerate dye to complete circuit

→ Iodide electrolyte is added to help the dye regain lost e⁻s.

→ I^- ions get oxidised to I_3^-

→ Free e⁻s at graphite plate reduce I_3^- to I^-

→ Thus dye molecules are ready for next cycle.

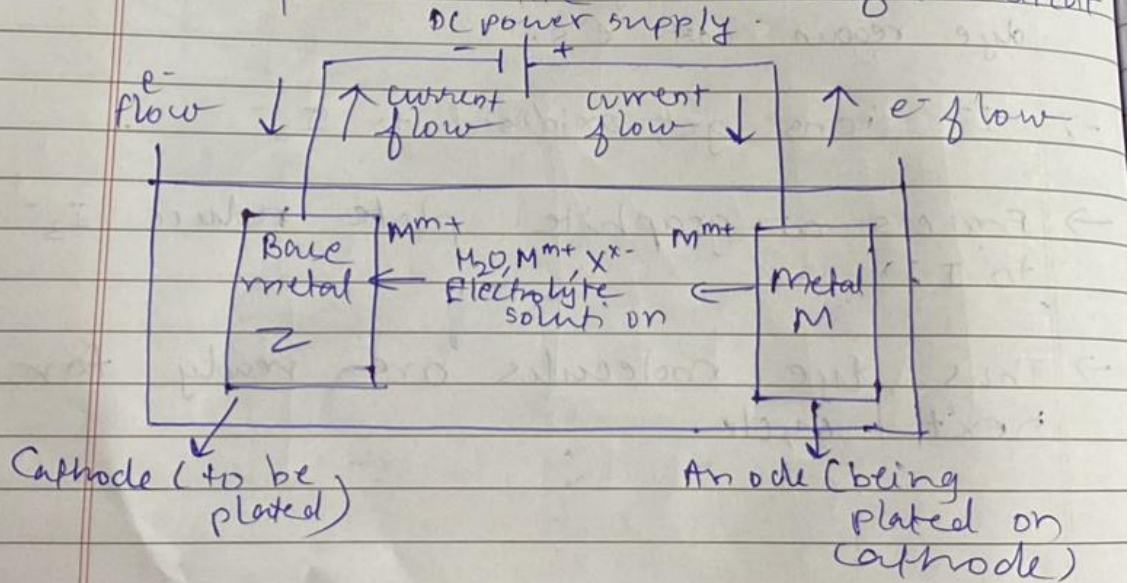
Electroplating

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 circuit



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

Objectives

→ decorative appearance
→ Improved thermal resistance
→ Improved corrosion resistance
→ Improved chemical resistance

Fuel cell

Fuel cells

→ Electrical energy is obtained without combustion from oxygen & a 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, excellent catalyst for reactions that take place on their surfaces, not deteriorating by electrolyte heat or electrode reactions.

→ Graphite impregnated with finely divided platinum or alloy of Pd, Ag & Ni serves the purpose of it hydrogen is the fuel.

→ Electrolyte:- aqueous KOH or H_2SO_4

Some major types of fuel cells are:-

1) Hydrogen Oxygen Fuel Cell (HOFC)

2) PEMFCs (Proton exchange or polymer electrolyte membrane)

3) AFCs (Alkaline)

4) PAFCs

5) MCFCs

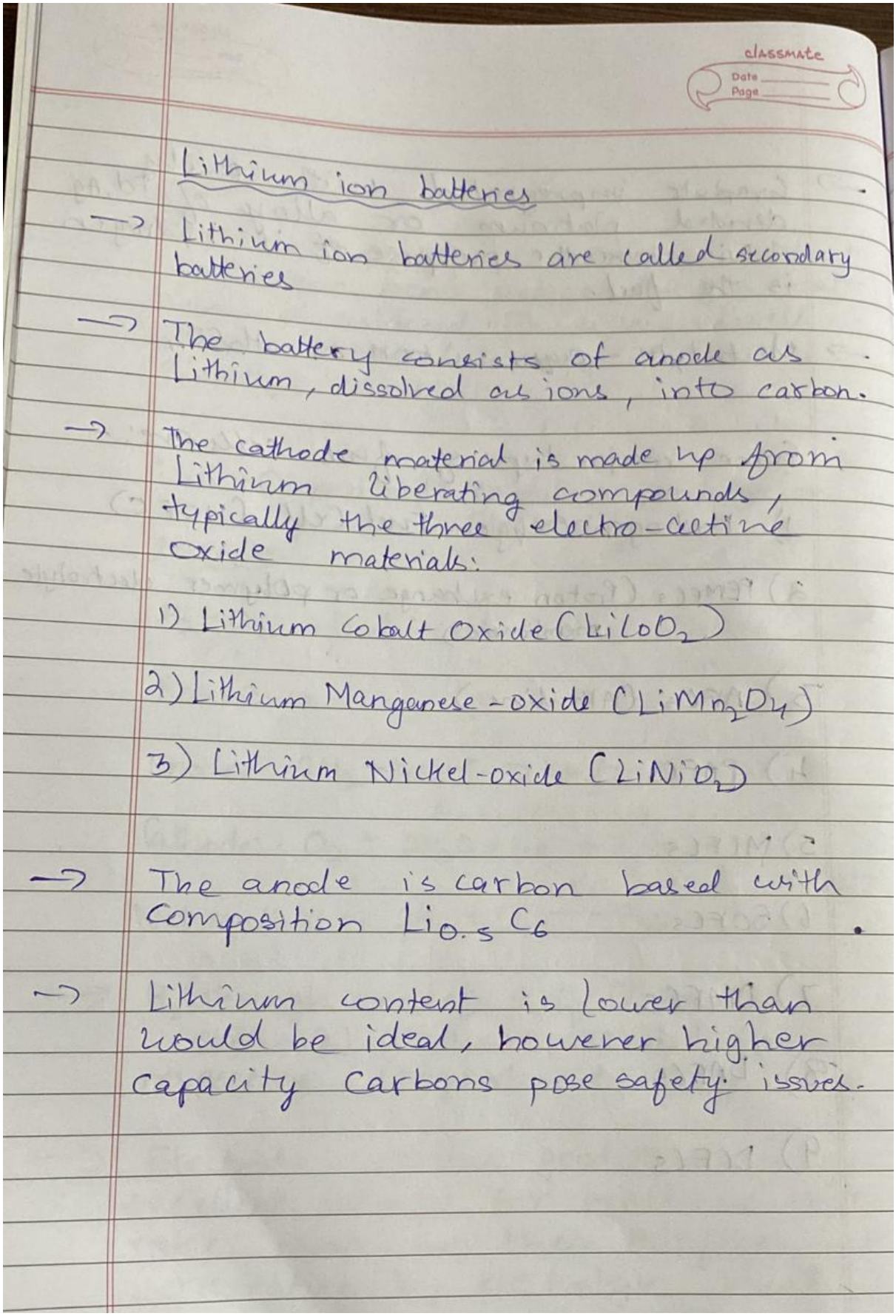
6) SOFCs

7) DMFCs

8) DAFCs

9) DCFCs

Lithium-ion batteries



Lithium ion batteries

→ Lithium ion batteries are called secondary batteries

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

→ 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 ($LiNiO_2$)

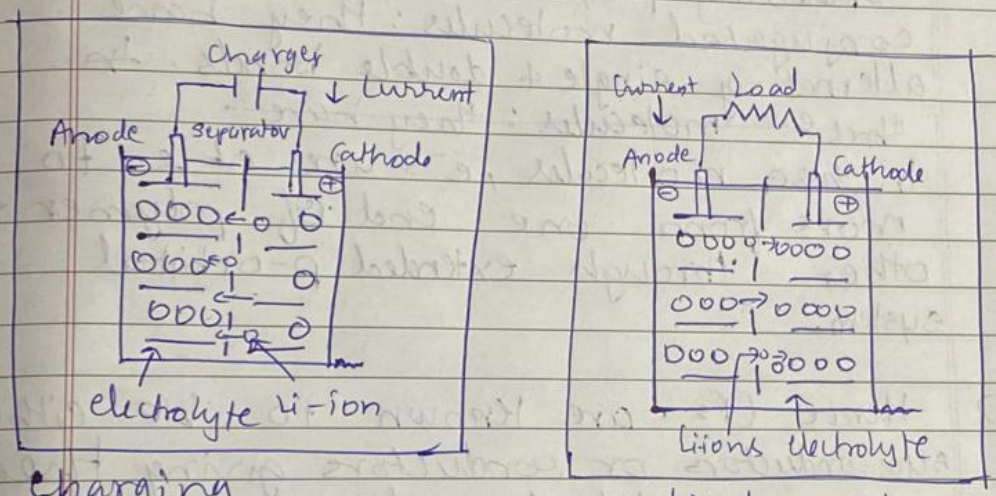
→ The anode is carbon based with composition $Li_{0.5}C_6$

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

→ Electrolyte - Since Lithium reacts violently with water and the cell voltage is so high that water would decompose, a non-aqueous electrolyte must be used.

→ A typical electrolyte is $LiPF_6$ dissolved in an ethylene carbonate & dimethyl carbonate mixture.

→ Taking $LiCoO_2$ let's see charging & discharging



charging

Anode

$Li_{1-x}CoO_2 + CnLi_x \rightarrow LiCoO_2 + Cn$

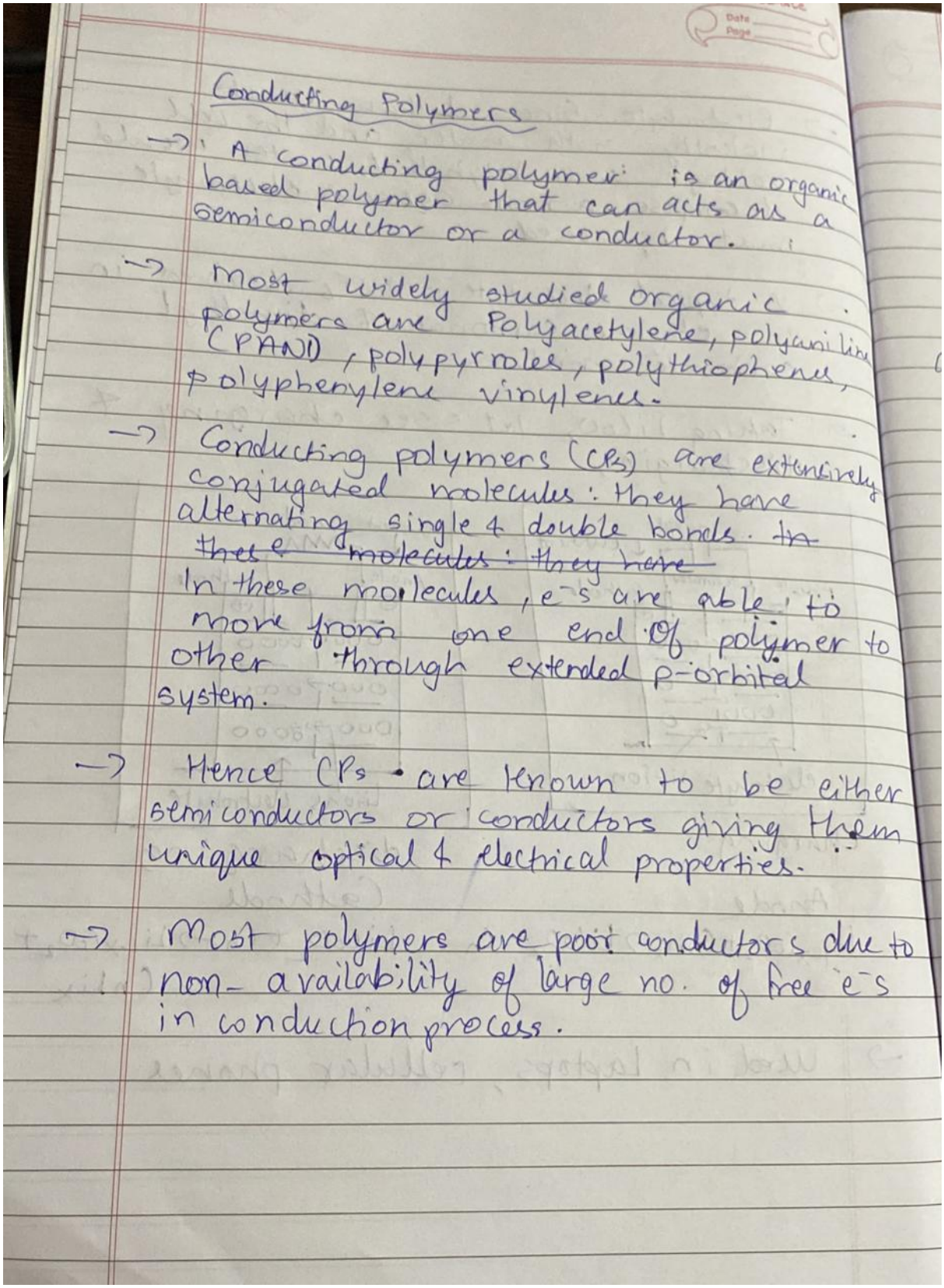
discharging

Cathode

$LiCoO_2 + Cn \rightarrow Li_{1-x}CoO_2 + CnLi_x$

→ Used in Laptops, cellular phones

Conducting polymers



Conducting Polymers

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

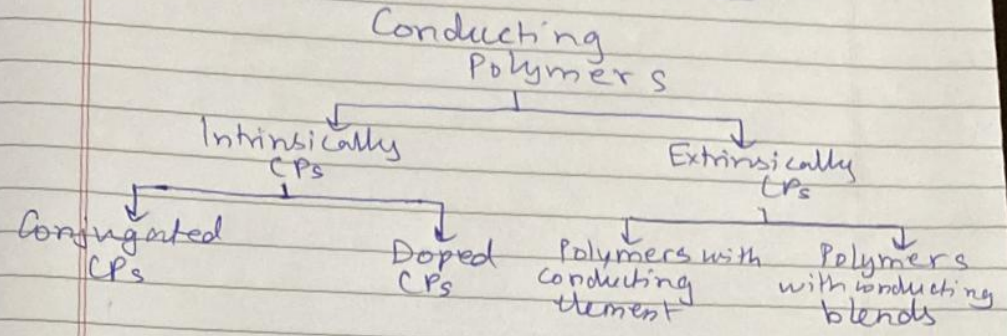
→ Most widely studied organic polymers are Polyacetylene, polyaniline (PANI), polypyrroles, polythiophenes, polyphenylene vinylenes.

→ Conducting polymers (CPs) are extensively conjugated molecules: they have alternating single & double bonds. ~~In these molecules: they have~~ In these molecules, e⁻s are able to move from one end of polymer to other through extended p-orbital system.

→ Hence CPs are known 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.