BCHY101L - Digital Assignment II

Q1 Secondary Lithium Ion Battery :

→ Anode : Lithium Intercalated graphite (LIG)

→ Cathode : Lithiated Transition metal oxides : $LiMnO_2$, $LiCoO_2$, $LiNiO_2$, $LiFePO_4$

→ Electrode : $LiPF_6$, $LiClO_4$ or $LiAsF_6$ in PC or EC

PC → Propylene Carbonate
EC → Ethylene Carbonate

→ Separator :
Polyethylene Oxides (PEO), Polyvinylidene Fluoride

→ Reactions :

- Anode : $CLi_x \xrightleftharpoons[\text{charge}]{\text{discharge}} CLi_{x-n} + nLi^+ + ne^-$
- Cathode : $LiCoO_2 + ne^- + nLi^+ \xrightleftharpoons[\text{charg.}]{\text{discharg.}} Li_{1+n}CoO_2$

- Net Reaction : $CLi_x + LiCoO_2 \xrightleftharpoons[\text{charg.}]{\text{discharg.}} CLi_{x-n} + Li_{1+n}CoO_2$

→ Basic cell reaction at secondary lithium ion battery is the migration of Li^+ between +ve and -ve electrodes.
→ It operates at around 4V.
→ As it is a secondary battery, it is rechargable which is seen in the reaction.
→ Advantages : High energy density, Low self discharge, Good Cycle life

→ **Working:**

- Chemical transformation of electrode materials and electrolyte only.
- Graphite layered intercalated with Li between the layers to form Graphite Intercalation Compound (GIC).

- Lithium ion can be electrochemically reduced in graphite layer to form Li-GIC.

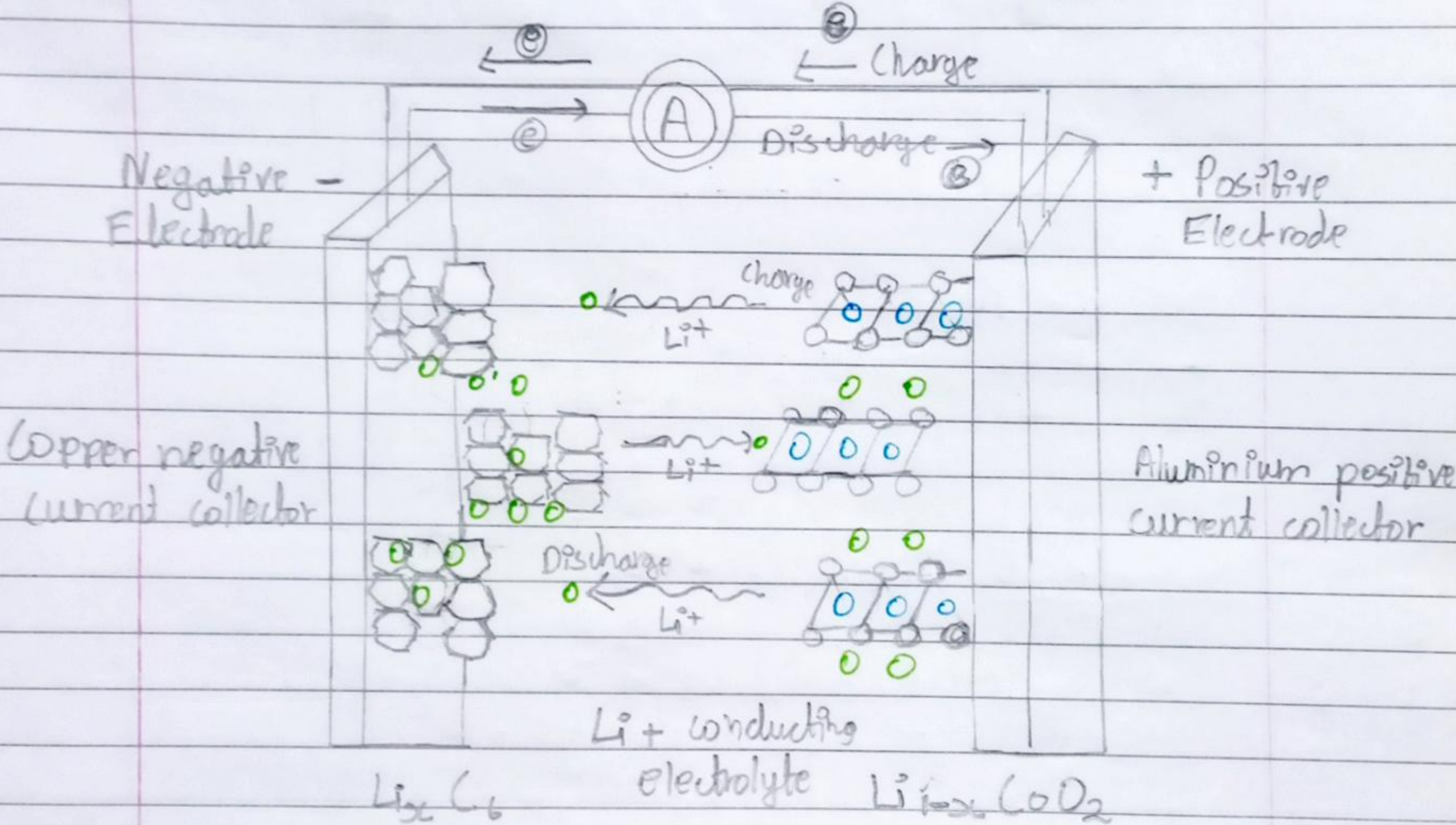
- Rocking Chair Batteries:

  * During charging lithium is extracted by de-intercalation from layered $LiCoO_2$ cathode.
  * The extracted Li^+ is intercalated by electrochemical reduction into graphite anode to form Li-GIC.
  * Opposite of above process happens during discharging.
  * As lithium rocks between the electrodes during the process it is called 'rocking chair batteries', 'swing batteries' or 'shuttlecock batteries'.

- Cell Structure:

  * Cu and Al foils are used as anode and cathode current collector respectively.
  * For cathode, $LiCoO_2$ powder is mixed with polyvinylidene fluoride binder in an appropriate solvent and is coated over cathode active matrix.
  * Anode is prepared in similar manner by using carbon powder instead of $LiCoO_2$.
  * A microporous polyethylene film soaked in electrolyte (Li salt in PC-EC) is used as separator

Lithium Ion Battery



Q2 **Solid Oxide Fuel Cells:**

→ Fuel cells, electrodes and electrolytes are oxides and solid materials (ceramic make-up)

→ **Fuel at:** ① Anode → H_2 + CO
② Cathode → O_2

→ **Electrolyte:** Yttria (Y_2O_3) stabilised Zirconia (ZrO_2)
↳ High O^{2-} conductivity over wide range of temperature and pressure.

* Rare earth doped CeO_2 and Bi_2O_3 can also be used as electrolyte solid.

→ **Anode:** Ni-Yttria stabilised Zirconia (Ni-YSZ)

→ **Cathode:** Lanthanum Manganate ($LaMnO_3$)

→ **Charge Carrier:** O_2

→ **Operating temperature:** 1000°C

→ **Efficiency:** 50-60%

- Fuel-to-electricity efficiencies of solid oxide fuel cells = 50%
- Hot exhaust to run gas turbines efficiency = 60%
- Capture and utilize the system's waste heat efficiency = 80-85%

→ Pollution-free power generation.
→ Does not require noble metal catalyst
→ Reliable, fuel conserving.
→ Hot exhaust of the cells is used in a hybrid combination with gas turbines.

→ Working:

- O_2 supplied at cathode is reduced to O^{2-}. It migrates to anode through oxygen-ion conducting electrolyte (YSZ)

- At anode O^{2-} combine with H_2 to form water and liberate e^-.

- e^- flows from anode through the external circuit to the cathode.

- Reaction at Cathode : $\frac{1}{2}O_2 + 2e^- \longrightarrow O^{2-}$

Air electrode operates at 1000°C and participates in oxygen reduction.

- Reaction at Anode : $H_2 + CO + 2O^{2-} \longrightarrow H_2O + CO_2 + 2e^-$

-Fuel electrode must be stable under reducing environment of the fuel. It should be electronically conducting.
- It must have sufficient porosity for the passage of fuel beyond electrode-electrolyte interface for oxidation of fuel

→ Reaction rate at operating temperature (100°C) is high, so no noble metal catalyst needed

→ Catalyst used ~~are~~ can not be sensitive to CO to avoid CO poisoning the electrodes

→ Considered for large power plants and industrial application.

Solid Oxide Fuel Cells