Lecture 1:

I) Introduction to Battery and Fuel Cells:

A) What is an electrochemical cell ?

B) Batteries (Energy and Power density, efficiency)

C) Fuel Cells (Phosphoric acid Fuel Cell, Akaline Fuel Cell)

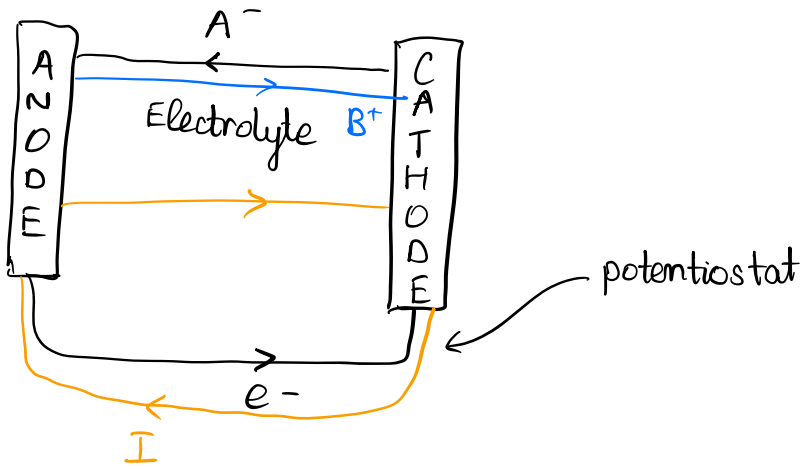
I) A) Electrochemical cell :

Components : Two electrodes (Cathode and Anode)
(WE and CE - if people want to study the kinetic at one electrode)

Electrolyte (flow of ions)

External conductor (flow of electrons)
↳ external circuits

Representation :

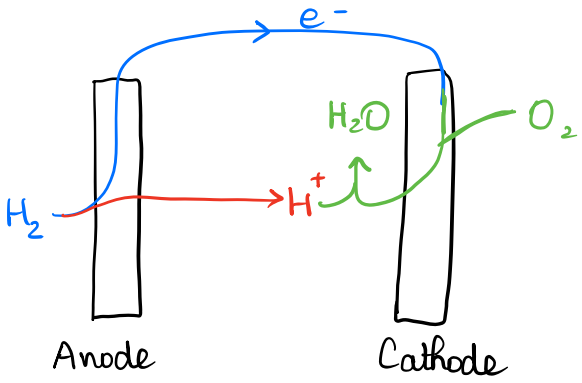


Electrode (mobile species : electrons) : conductivity 10^2 to 10^4 S/cm
e.g : Metal , semiconductor

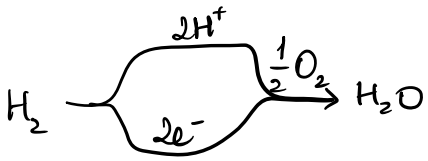
Electrolyte (mobile species : ions, NO electrons) : conductivity 10^{-4} to 10^{-1} S/cm
e.g : dissociated salt , molten salt , polymer (Nafion, FAA)

Difference between electrochemical reaction and chemical reaction

Electrochemical rxn



generate electricity



electron pass through potential difference between 2 electrodes

Chemical rxn

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$$

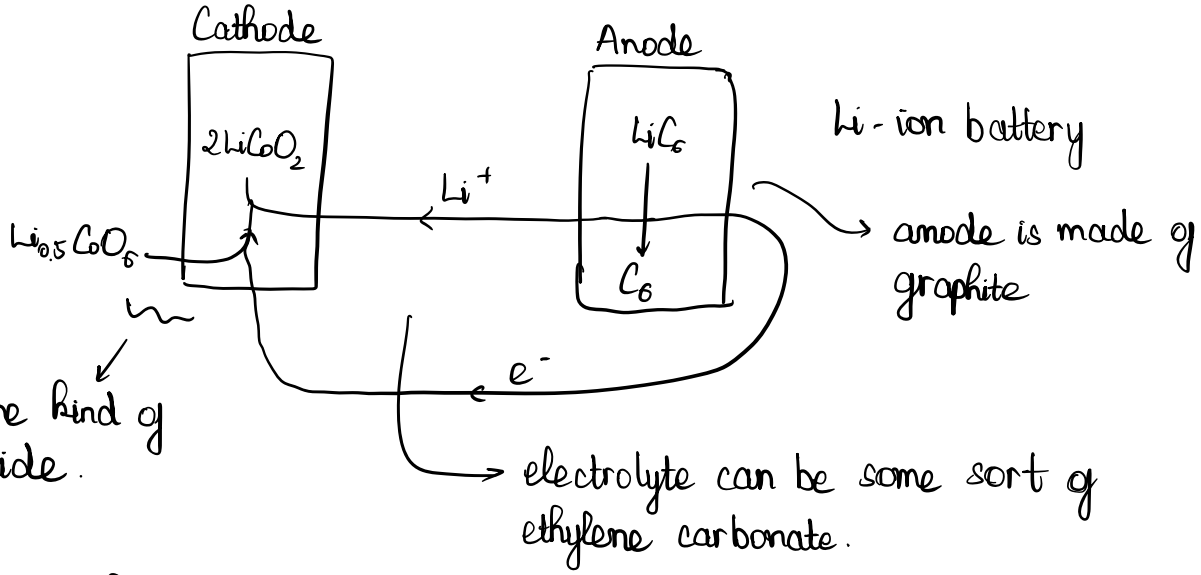
generate heat

electron pass through potential difference between two nuclei

B) Batteries:

A "self-contained" electrochemical device which stores electrical energy.

Discharged reaction: $LiC_6 + 2Li_{0.5}CoO_2 \longrightarrow C_6 + 2LiCoO_2$



- Primary → Non-rechargeable
- Secondary → Rechargeable

Metric:

	Gravimetric	Volumetric
Capacity	$Q_g = \frac{Q}{m} = \frac{nF}{MW}$	$Q_v = \frac{Q}{V}$
Energy Density	$Q_g.V$	$Q_v.V$
Power Density	$i_g.V$	$i_v.V$

where $Q = n.F.N_m$ → moles of reactant being consumed

↓ # electrons per each reactant

$$\underline{C\text{-rate}} = \frac{i}{Q} \quad [=] \quad \frac{1}{\text{time}}$$

(i ← C/s, Q ← C)

e.g: $3\ \frac{1}{\text{hour}}$ means the cell is fully discharged in $\frac{1}{3}$ hour

Efficency:

On a charge basis: $q_c = \frac{Q_d}{Q_c}$ (Q_d ← discharge, Q_c ← charge) — Columbic Efficiency

On an energy basis: $q_E = \frac{Q_d . V_d}{Q_c . V_c}$

Examples of battery:

Primary:

Battery	Anode	Cathode	reaction	U	Capacity (A.h/kg)
Leuanche	Zn	MnO_2	$Zn + MnO_2 \rightarrow ZnO + Mn_2O_3$	1.6 V	224
Zinc - Air	Zn	O_2	$Zn + 1/2\ O_2 \rightarrow ZnO$	1.65 V	658
Li - MnO_2	Li	MnO_2	$Li + MnO_2 \rightarrow LiMnO_2$	3.1 V	286

Secondary

Battery	Anode	Cathode	reaction	U	Capacity (A.h/kg)
Lead acid	Pb	PbO_2	$PbO_2 + H_2SO_4 \rightarrow PbSO_4 + H_2O$	2.1 V	120
Nickel - Cadmium	Cd	NiOOH	$Cd + 2NiOOH \rightarrow Ni(OH)_2 + Cd(OH)_2$	1.35	181

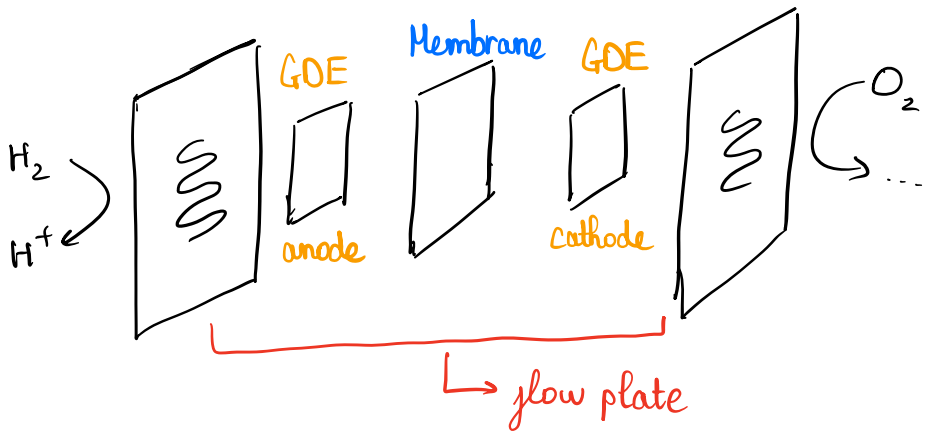
C) Fuel Cells:

An electrochemical cell which converts chemical energy of a fuel into electricity → Not "sely-contained" device

Typically O_2 and H_2 / CH_3OH / N-based substances

→ Harness energy from oxidation reaction

Example: H_2/O_2 fuel cell



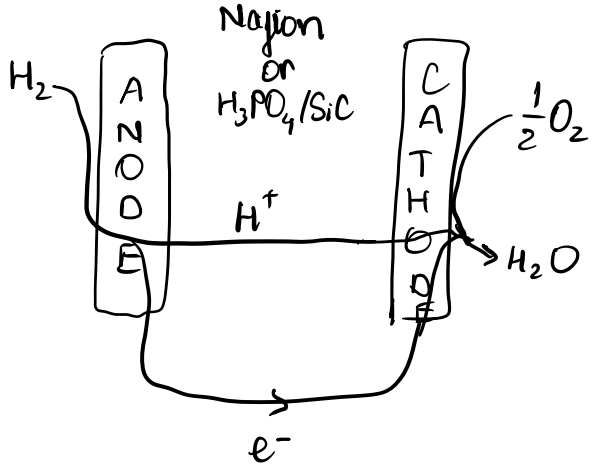
H_2/O_2 fuel cell can operate in acid or basic conditions

phosphoric acid fuel cell
PEM fuel cell

alkaline fuel cell
AAEM fuel cell

↳ commercially available

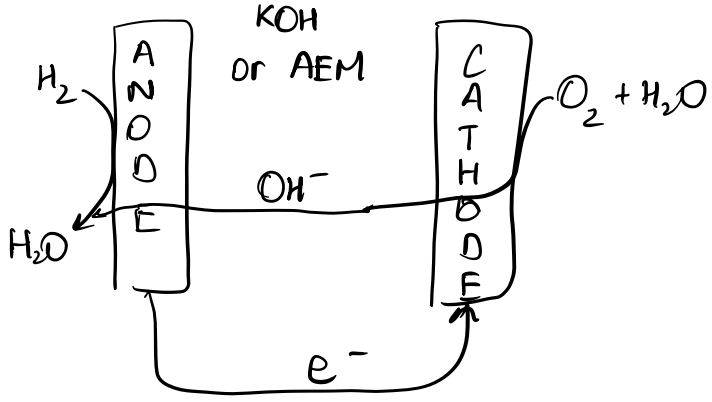
Acid condition:



GDE is typically made up of Pt/C on carbon cloth.

Disadvantage: ORR is slow in acidic condition

Basic condition:



GDE can be non-precious metal

Disadvantage: AEM has low ionic conductivity

CO_2 accumulation if O_2 is taken from ambient air