Chemical potential if $f = 1$

$$\mu_i^{\circ} = \mu_i^{*} + RT \ln f^{\circ} \longrightarrow \text{fugacity of pure Substance}$$

Same Compound in other State

$$\mu_i = \mu_i^{*} + RT \ln(f) \rightarrow$$

difference in Chemical potential

$$\mu_i - \mu_i^{\circ} = \mu_i^{*} + RT \ln f - (\mu_i^{*} + RT \ln f^{\circ})$$

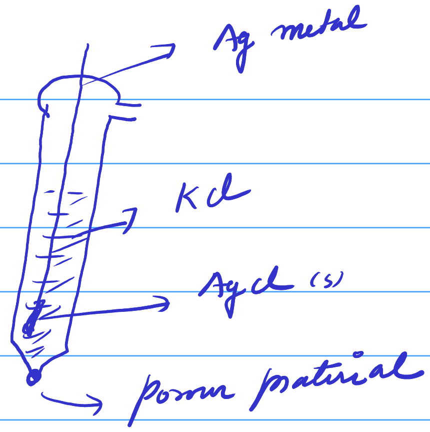
$$= RT \ln (f/f^{\circ})$$

$$\Downarrow \; a \rightarrow \text{activity}$$

for a substance in pure form

$f = f^{\circ}$

so $a = 1$



Silver - Silver Chloride Electrode

Representation

$$Cl^-_{(aq, a_1)} \,|\, AgCl_{(s)} \,|\, Ag_{(s)}$$

Reaction :-

$$AgCl_{(s)} + 1e^- \rightarrow Ag_{(s)} + Cl^-$$

Potential @298K

$$E = E^0 - \frac{0.0592}{1} \log a_{Cl^-}$$

$$E \propto a_{Cl^-}$$

Commonly Used Concentration

Sat. KCl $\rightarrow$ 0.199V

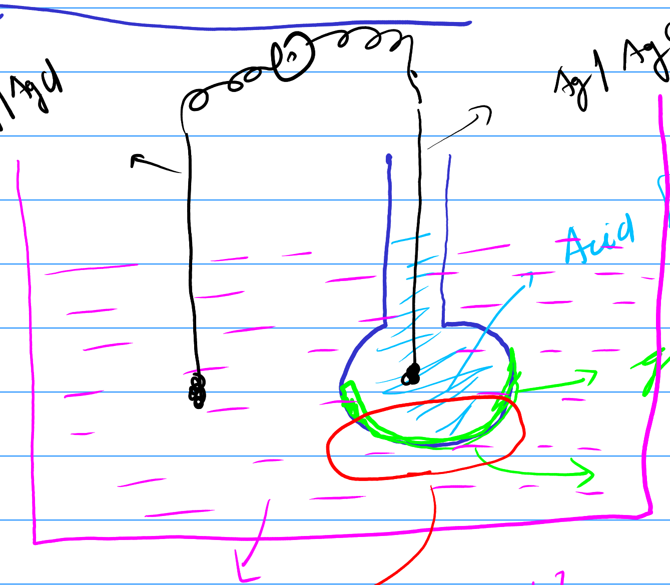
1M KCl $\rightarrow$ 0.23V

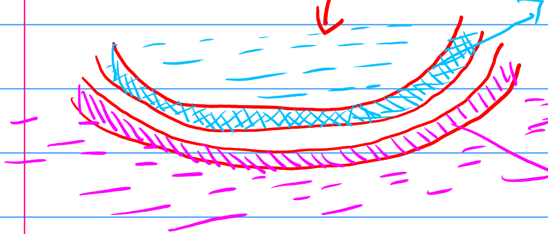
Ion-Selective electrode

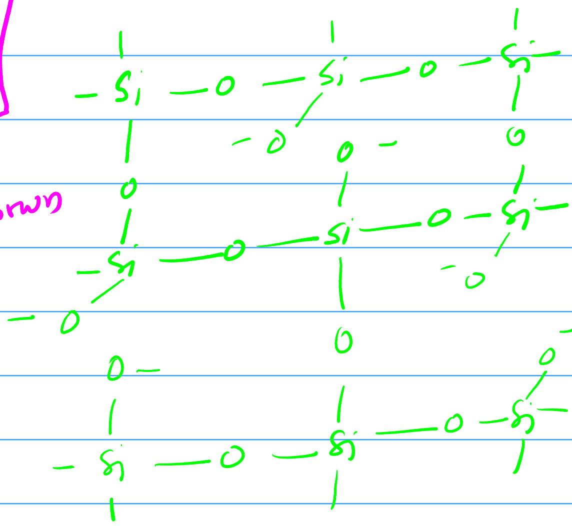
$\rightarrow Na^+, Ca^{2+}, NH_4^+, CN^-, S^{2-}, H^+ \ldots$

$H^+ \rightarrow$ pH electrode

Glass membrane electrode







$SiO^- + H^+ \rightarrow SiOH$

if $[H^+]_{known} \neq [H^+]_{unknown}$

→ no of SiO^- bond in & out are different

So there exist a phase boundary potential

Potential @ 298 K

$$E = E_R - E_L$$

$E_L \rightarrow$ Potential of Outer Reference $\{E_{OR}\}$

$$E_R \rightarrow E_B + E_{IR}$$

$E_{IR} \rightarrow$ Potential of inner reference

$E_B \rightarrow$ Phase boundary Potential

$$E_B \rightarrow E_{in} - E_{out}$$

$$E_B = E^0 - 0.0592 \log \frac{1}{[H^+]_{in}} - \left(E^0 - 0.0592 \log \frac{1}{[H^+]_{out}}\right)$$

$$= +0.00592 \log [H^+]_{in} - 0.0592 \log [H^+]_{out}$$

$[H^+]$ is fixed inside we can consider this as a constant

$$= \text{Constant} - 0.0592 \log [H^+]_{out}$$

$$= \text{Constant} + 0.0592 (-\log [H^+]_{out})$$

$$E_B = \text{Constant} + 0.0592\ pH$$

$$E_{cell} = E_B + E_{IR} - E_{OR}$$

$E_{OR} \rightarrow$ Potential of outer reference

$$= \text{Constant} + 0.0592\, pH + \underbrace{E_{IR}}_{\text{Reference}} - \underbrace{E_{OR}}_{\text{reference}}$$

Constant

$$\boxed{E_{cell} = \text{Constant} + 0.0592\, pH}$$

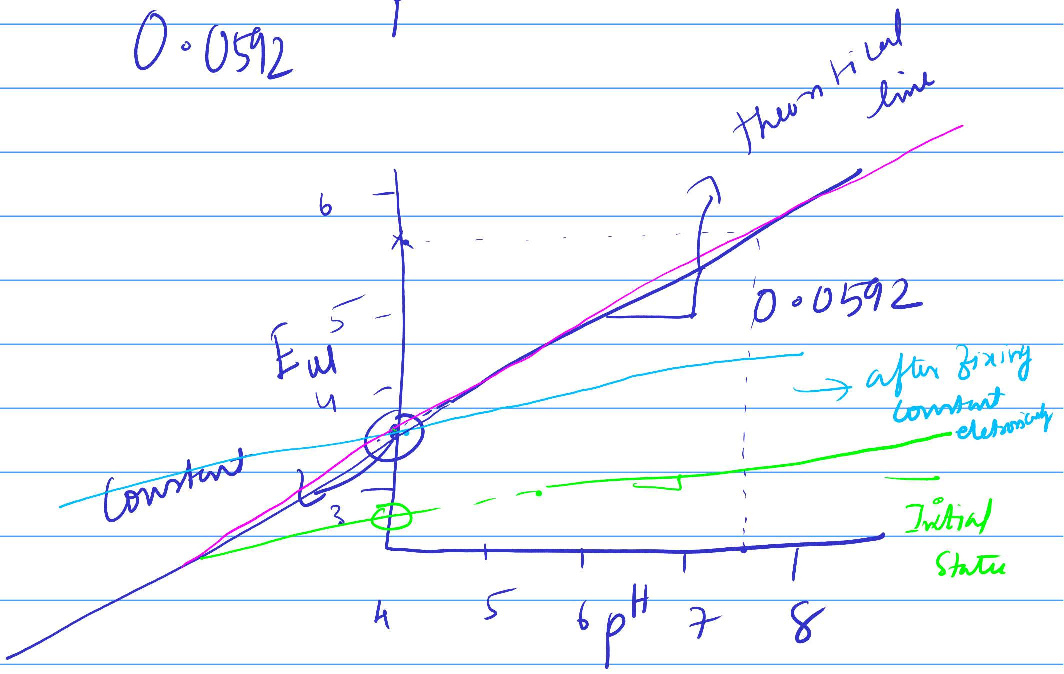
$$y = mx + c$$

y → Ecell

m → 0.0592

x → pH

c → Constant



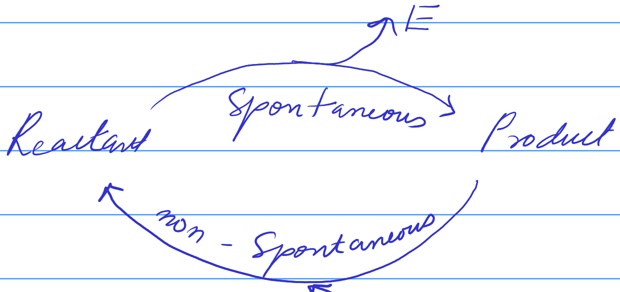
Batteries

Primary cell

1. reaction Can not be reversed
2. When all reactant are converted to product no electricity

Sec. cell

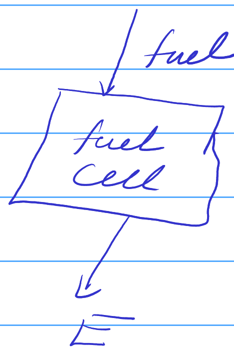
1. reaction Can be reversed by applying external potential



Σ run non-Spontaneous Chemical reaction @ the expense of electricity

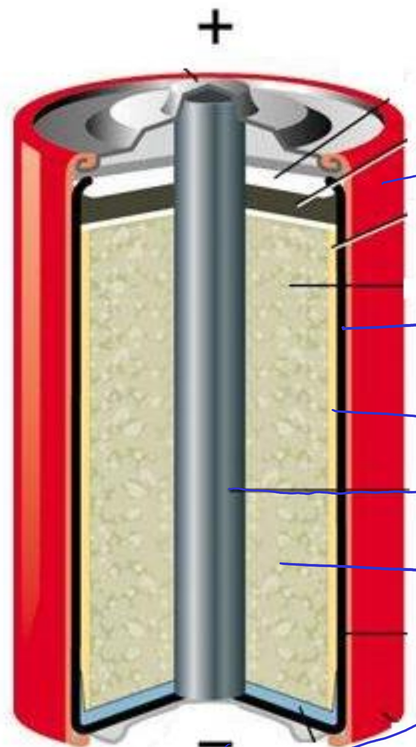
Flow cells / Fuel cell

1. Continious feed of fuel to generate electricity



Primary cell

Lechlanche cell / dry cell → no free flowing liquid



Outer metal cover

Zinc metal

Porous material {Papers}

graphite rod

Wet $MnO_2 + C$ + $NH_4Cl + ZnCl$ → electrolyte

role of Carbon black → to bind MnO_2 with graphite

anode: Zinc metal

Cathode: MnO_2 / graphite rod

Electrolyte: NH_4Cl

Max. output: 1.5 V

representation:

$$Zn_{(s)} \,|\, ZnCl_{2(s)} \,|\, NH_4Cl_{(s)} \,|\, MnO_{2(s)} \,|\, graphite$$

@ anode

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

@ Cathode

$$2MnO_2 + \cancel{H_2O} + 2e^- \longrightarrow Mn_2O_3 + \cancel{2OH^-}$$

$$\cancel{2OH^-} + 2NH_4Cl \longrightarrow \cancel{2NH_3}\uparrow + \cancel{2}H_2O + 2Cl^-$$

$$\cancel{2NH_3} + ZnCl_2 \longrightarrow Zn(NH_3)_2Cl_2$$

$$2MnO_2 + 2e^- + 2NH_4Cl + ZnCl_2 \longrightarrow Mn_2O_3 + H_2O + 2Cl^- + Zn(NH_3)_2Cl_2$$

Over all reaction :-

$$2MnO_2 + Zn + 2NH_4Cl + \cancel{ZnCl_2} \rightarrow \cancel{ZnCl_2} + Mn_2O_3 + H_2O + Zn(NH_3)_2Cl_2$$

$$\boxed{2MnO_2 + Zn + 2NH_4Cl \rightarrow Mn_2O_3 + H_2O + Zn(NH_3)_2Cl_2}$$

Alkali Cell

Advanced dry cell

anode :- Zn

Cathode : MnO_2/C

Electrolyte : KOH

Cell out put = 1.5

@ anode :

$$Zn \rightarrow Zn^{2+} + 2e^-$$

@ Cathode

$$2MnO_2 + H_2O + 2e^- \rightarrow Mn_2O_3 + 2OH^-$$

$$Zn + 2MnO_2 + H_2O \rightarrow Mn_2O_3 + Zn(OH)_2$$

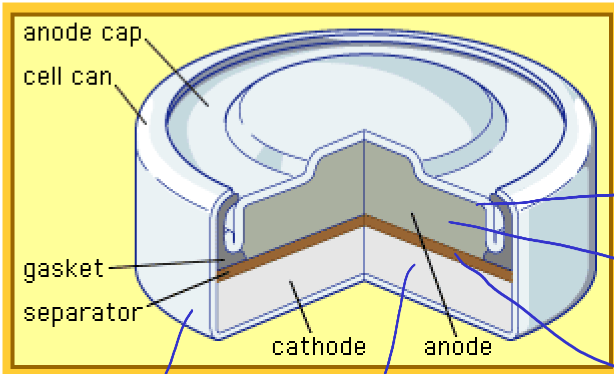
$$\downarrow$$

$$ZnO + H_2O$$

Over all reaction

$$Zn + 2MnO_2 \rightarrow Mn_2O_3 + ZnO$$

Ag_2O - Zinc cell



Zinc {anode}

wet. Sat. KOH/ZnO

Porous material {paper}

Ag_2O

Metal {S.S}

anode: Zinc metal

Cathode: Ag_2O / metal

electrolyte: Wet. Sat. KOH

Max out: 1.8 V

$$Zn \,|\, ZnO \,/\, KOH \,||\, Ag_2O \,/\, Metal$$

@ anode:-

$$Zn \longrightarrow Zn^{2+} + 2e^-$$

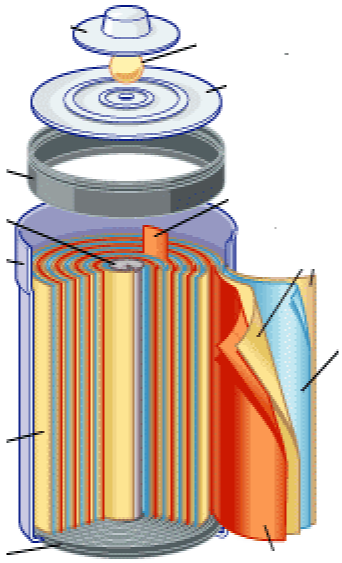
@ Cathode

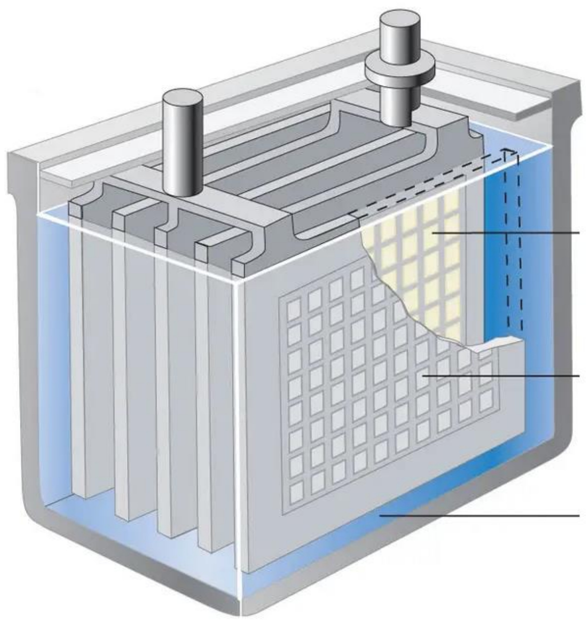
$$Ag_2O + H_2O + 2e^- \longrightarrow 2Ag + 2OH^-$$

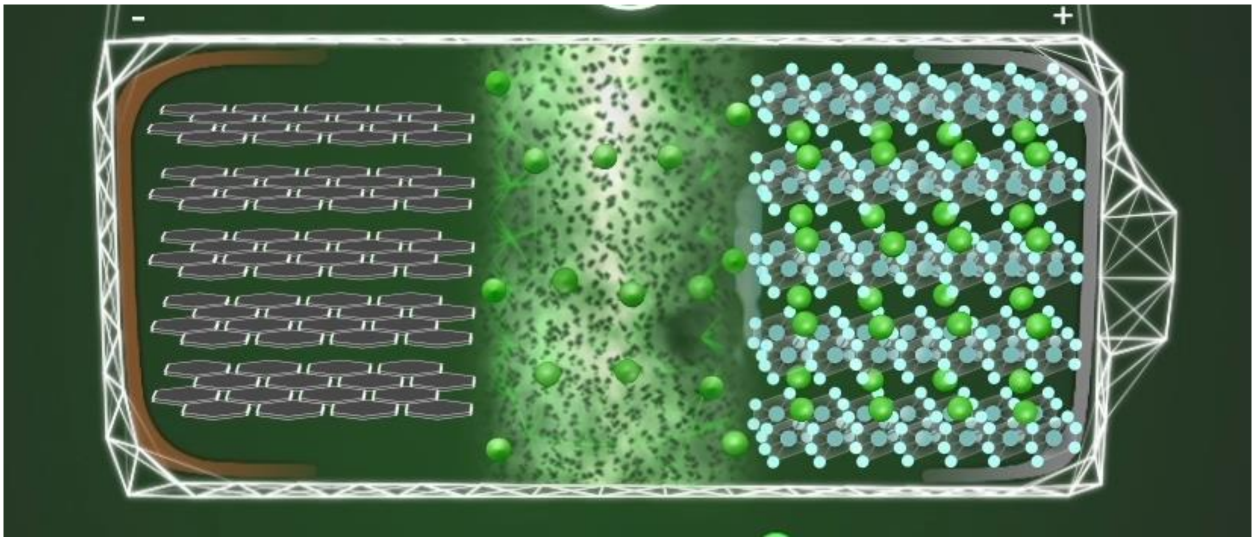
$$Zn + Ag_2O + \cancel{H_2O} \longrightarrow 2Ag + Zn(OH)_2$$

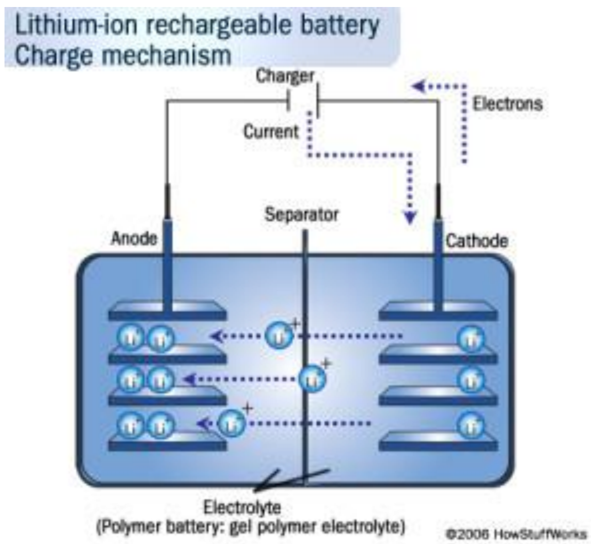
$$Zn(OH)_2 \rightarrow ZnO + H_2O$$

$$Zn + Ag_2O \longrightarrow 2Ag + ZnO$$








Lithium-ion rechargeable battery
Charge mechanism
Charger
Electrons
Current
Separator
Anode
Cathode
Electrolyte
(Polymer battery: gel polymer electrolyte)
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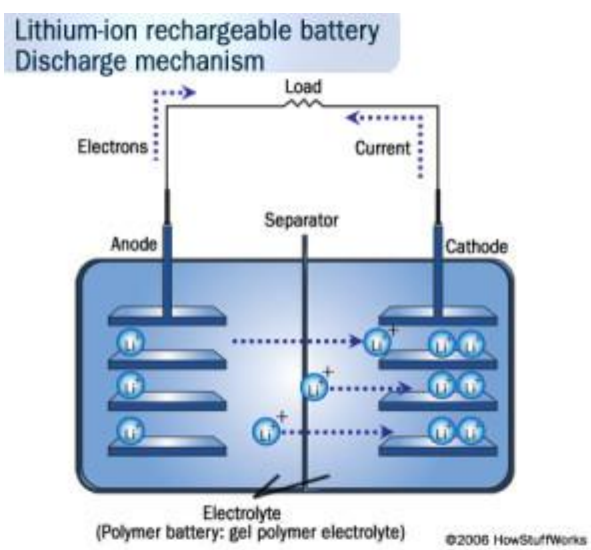
Lithium-ion rechargeable battery
Discharge mechanism
Load
Electrons
Current
Separator
Anode
Cathode
Electrolyte
(Polymer battery: gel polymer electrolyte)
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