Electro Chemistry

Electrochemical cell:-

A device which converts chemical energy into electrical energy (or) the electrical energy is converted into chemical energy by redox reactions.

The electrochemical cells are classified into two types

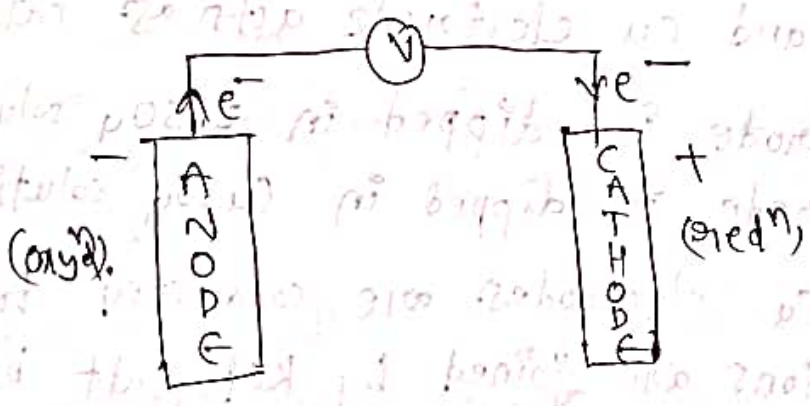
(i) Galvanic cell (or) Voltaic cell.

(ii) Electrolytic cell.

Galvanic cell:-

A device which converts chemical energy into electrical energy by redox reactions is known as galvanic cell.

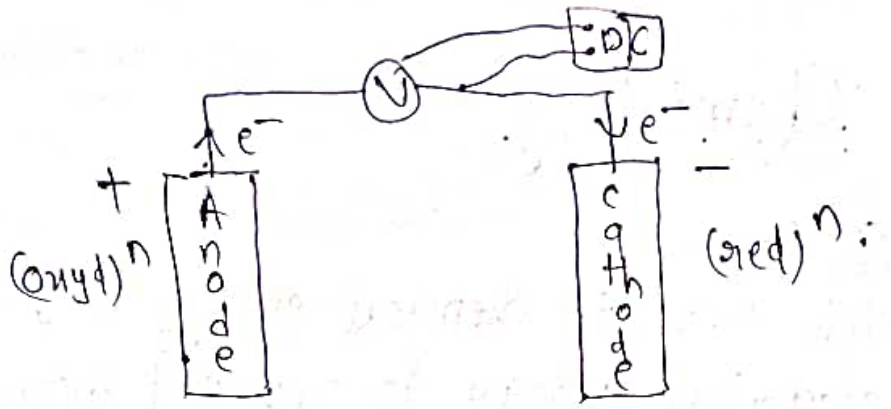
In galvanic cell the redox reactions are spontaneous



Electrolytic cell:-

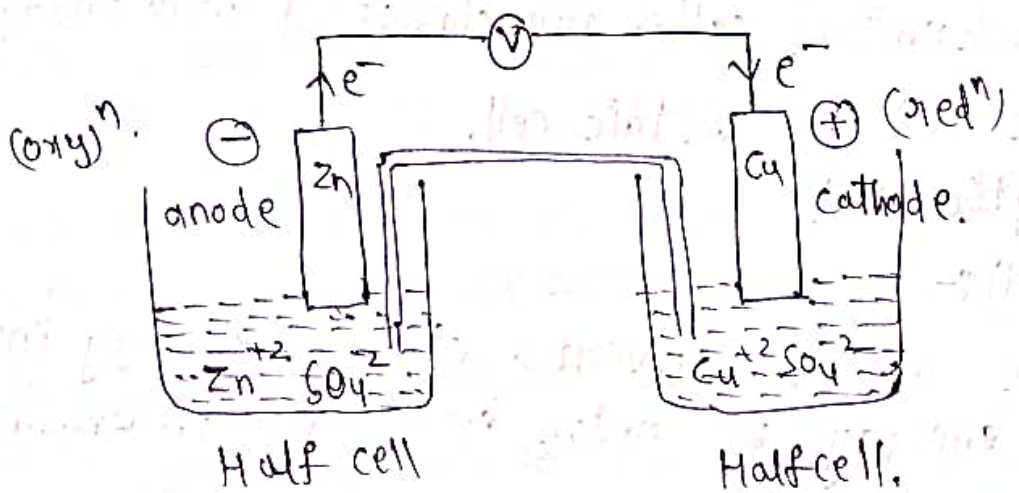
A device which converts electrical energy into chemical energy by redox reactions is known as electrolytic cell.

In electrolytic cell the redox reactions are non-spontaneous.



Q. Explain the danial cell (Zn-Cu).

Sol:



Daniel cell is a galvanic cell. It is constructed by Zn and Cu electrodes. Zn electrode acts as anode (-ve) and Cu electrode acts as cathode (+ve).

The Zn electrode is dipped in $ZnSO_4$ solution and the Cu electrode is dipped in $CuSO_4$ solution

The Zn and Cu electrodes are connected to voltmeter. The two solutions are joined by KCl salt bridge. which maintains chemical imbalance of two solutions.

During the galvanic cell oxydⁿ reactions occurs at anode and redⁿ reactions occurs at cathode.

At anode Zn electrode loosing the e^- and forms Zn^{+2} ions which are dissolved in the solution.

At cathode the Cu^{+2} ions from the solution discharged over the Cu electrode by gaining of e^- from anode.

The e^- are flow from anode electrode to cathode electrode which can generate the electricity (voltage).

At anode : $Zn \longrightarrow Zn^{+2} + 2e^-$ (oxyd^n) (Half cell)

At cathode : $Cu^{+2} + 2e^- \rightarrow Cu$ (red.^{n}) (Half cell)

Net Reaction : $Zn_{(s)} + Cu^{+2}_{(aq)} \rightarrow Zn^{+2}_{(aq)} + Cu_{(s)}$

EME of cell (Cell Potential) :-

The potential difference of two electrodes is known as EMF of cell (or) Cell potential.

The emf of cell depends on the concentration of two solutions. It is measured in volts.

$$\epsilon^\circ_{cell} = \epsilon^\circ_{cathode} - \epsilon^\circ_{anode}$$

(or)

$$\epsilon^\circ_{cell} = \epsilon^\circ_{R} - \epsilon^\circ_{L}$$

Nernest Equation :-

The cell potential value and the individual electrode potential values at various concentrations can be measured by nernest equation.

$$\epsilon_{cell} = \epsilon^\circ_{cell} - \frac{2.303RT}{nF} \log \frac{[products]}{[reactants]}$$

$$\epsilon_{cell} = \epsilon^\circ_{cell} - \frac{0.0592}{n} \log \frac{[P]}{[R]}$$

$\because$ $R = 8.313\ J/k/m$

$T = 298^\circ K$

$F = 96000\ C/mole$

n = charge of ions $\quad E^\circ_{cell} = E^\circ_R - E^\circ_L$

Cation electrode potential:-

$$M^{+n} + ne^- \rightarrow M$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0592}{n} \log \frac{[M]}{[M^{+n}]}$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0592}{n} \log [M^{+n}]^{-1} \quad \downarrow [M] = 1$$

$$E_{cell} = E^\circ_{cell} + \frac{0.0592}{n} \log [M^{+n}]$$

Anion electrode potential:-

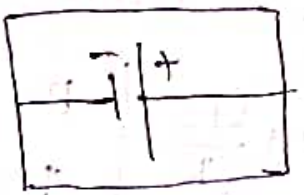
$$A + ne^- \rightarrow A^{-n}$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0592}{n} \log \frac{[A^{-n}]}{[A]}$$

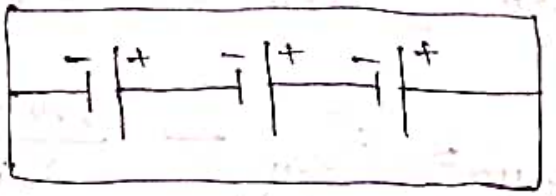
$$E_{cell} = E^\circ_{cell} - \frac{0.0592}{n} \log [A^{-n}] \quad \downarrow A = 1.$$

Batteries:-

A battery is an electrochemical cell. The several number of electro chemical cells are connected in a series to get more electricity.



2V. Battery



6V battery.

The batteries are classified into two types.

(i) Primary Batteries.

(ii) Secondary Batteries.

Primary Batteries:-

(i) The primary battery acts as galvanic cell.

(ii) When all the chemical energy converts into electricity then the battery will be discharged.

(iii) The primary batteries are called dischargable batteries.

(iv) The cell reaction is not reversible in primary batteries.

ex:- Mercury batteries, alkalene batteries.

Secondary Batteries:-

(i) The secondary batteries acts as galvanic cell as well as electrolytic cell.

(ii) The dischargible batteries can be recharged by passing external current.

(iii) The secondary batteries are called rechargable batteries.

(iv) The cell reaction is reversed by recharging of cell.

ex:- Ni – Cd Batteries

Pb – acid Batteries.

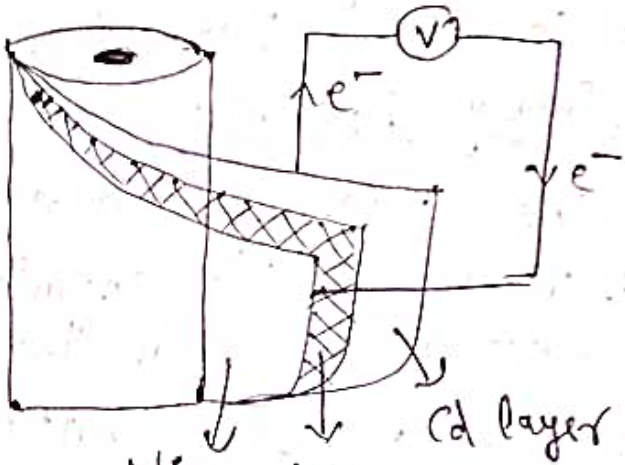
Li – ion Batteries.

Q. Explain the process of Ni-Cd Batteries?

Sol:- Anode : Cd

cathode : NiO_2

Electrolyte : KOH Solution (Seperator).



Discharging of cell:-

Cd and Ni oxide electrodes are rolled into a metal cylinder. The two electrodes are connected to voltmeter and which are seperated by KOH electrolytic solution (seperator).

At anode:- The Cd electrode is oxidised in the presence of KOH to form $Cd(OH)_2$

At cathode:- NiO_2 is reduced to form $Ni(OH)_2$.

At anode:- $Cd + 2OH^- \longrightarrow Cd(OH)_2 + 2e^-$ (oxyd^n)

At cathode:- $NiO_2 + 2H_2O + 2e \longrightarrow Ni(OH)_2 + 2OH^-$ (red^n)

$$Cd + NiO_2 + 2H_2O \xrightarrow{\text{discharging}} Cd(OH)_2 + Ni(OH)_2$$

Recharging of cell:-

The cell reaction is reversed by passing external current.

$$Cd + NiO_2 + 2H_2O \xleftarrow{\text{recharging}} Cd(OH)_2 + Ni(OH)_2$$

During the discharging and recharging of Ni-Cd battery.

$$Cd + NiO_2 + 2H_2O \underset{\text{recharging}}{\overset{\text{discharging}}{\rightleftharpoons}} Cd(OH)_2 + Ni(OH)_2.$$

(Q). Explain the process of Li-Ion battery?

Sol:- Li-Ion battery is the secondary battery. It acts as both galvanic cell and electrolytic cell.

In Li-Ion battery the flow of e^- is due to the flow of Li^+ ions b/w the electrodes. But the redox reactions are not involved.

Construction:-

Anode:- Graphite (C_6)

Cathode: $LiCoO_2$

Seperator: SPM (allows only Li^+ ions)

Electrolyte: Soluble salts of Li^+ ions.

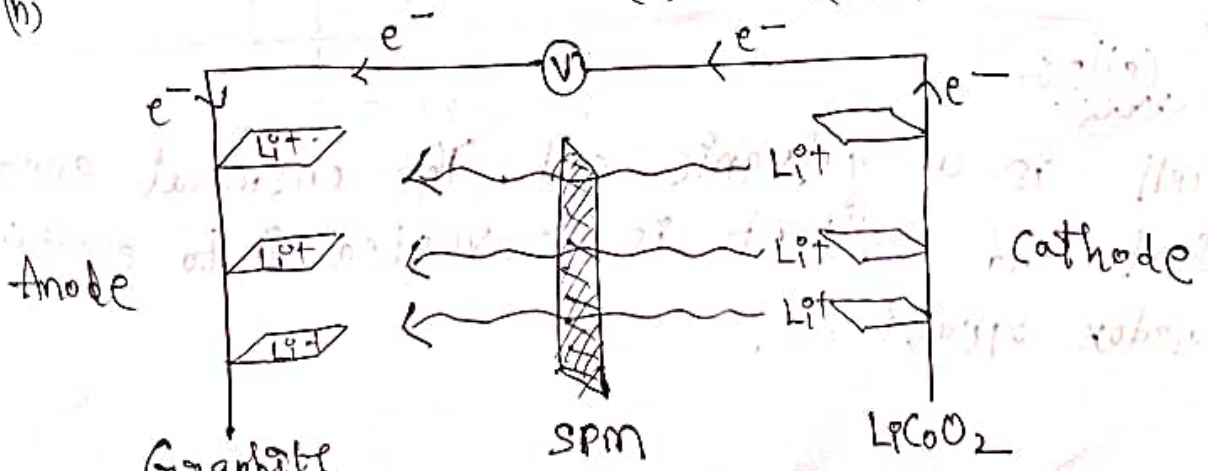
SPM = Semi Permeable Membrane.

Recharging of cell:-

$LiCoO_2$ gives Li^+ ions and e^-s. Li^+ ions are moving towards graphite through SPM and electrons are moving towards graphite through the external circuit. The flow of e^-s b/w the two electrodes generates voltage for current.

$$LiCoO_2 + C_6 \xrightarrow{\text{Recharging}} \underset{(x)}{LiC_6} + \underset{(n-x)}{LiCoO_2}$$

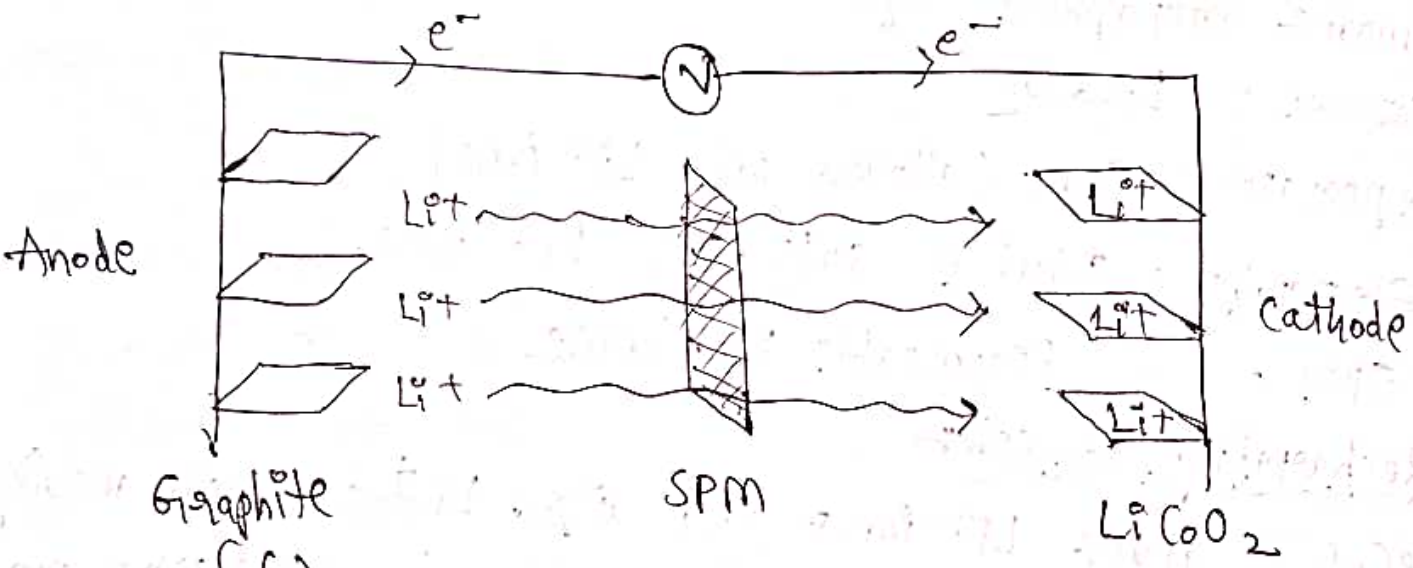
(n)



Discharging of cell:-

Li^+ ions and e^- from the graphite are moving back towards $LiCoO_2$. Li^+ ions are moving through the SPM and e^- are moving through the external circuit.

$$\underset{(n)}{LiCoO_2} + C_6 \xleftarrow{\text{discharging}} \underset{(x)}{LiC_6} + \underset{(n-x)}{LiCoO_2}$$



Net Reaction

During the recharging and discharging of cell.

$$\underset{(n),}{LiCoO_2} + C_6 \underset{\text{discharging}}{\overset{\text{recharging}}{\rightleftharpoons}} \underset{(x)}{LiC_6} + \underset{(n-x)}{LiCoO_2}$$

Fuel Cells:-

Fuel cell is a galvanic cell. The chemical energy of fuel and oxident is converted into electricity by redox reactions.

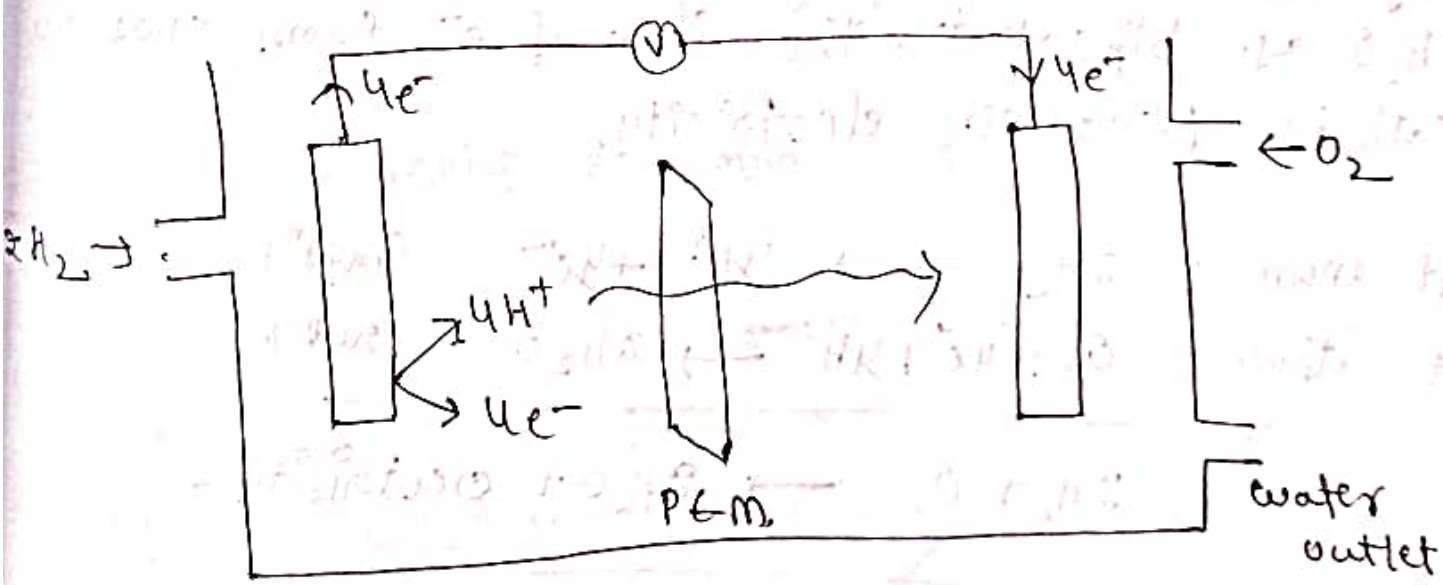
Components of Fuel Cell:-

* Fuel
* Oxident : O_2
* Anode porous electrode
* Cathode porous electrode
* Electrolyte
* PEM (Proton Exchange Membrane).

Q. Explain the process of H_2-O_2 Fuel cell.

Sol: Components of H_2-O_2 Fuel cell:-

* Fuel : H_2 gas
* oxident : O_2.
* Anode porous electrode : Composed of Pt catalyst
* Cathode porous electrode : Composed of CoO_2 catalyst
* Electrolyte : KOH solution.
* PEM (Proton Exchange Membrane).



Construction:-

Anode porous electrode and cathode porous electrode are connected to voltmeter and the electrodes are dipped in KOH solution.

The PEM is placed b/w the electrodes which allows only H^+ ions.

Working:-

The H_2 gas is passed through the anode porous electrode and the oxident (O_2) is passed through the cathode porous electrode from the outside of the cell.

At anode:- The H_2 is dissociated as $4H^+$ and $4e^-$. The $4H^+$ ions are moving towards the cathode through the PEM and the $4e^-$ are moving towards the cathode through the external circuit.

At cathode:- The e^-s from the anode are consumed by O_2 and combines with $4H^+$ ions to form H_2O as biproduct. The flow of e^- from anode to cathode produces electricity.

At anode : $2H_2 \longrightarrow 4H^+ + 4e^-$ (oxydn)

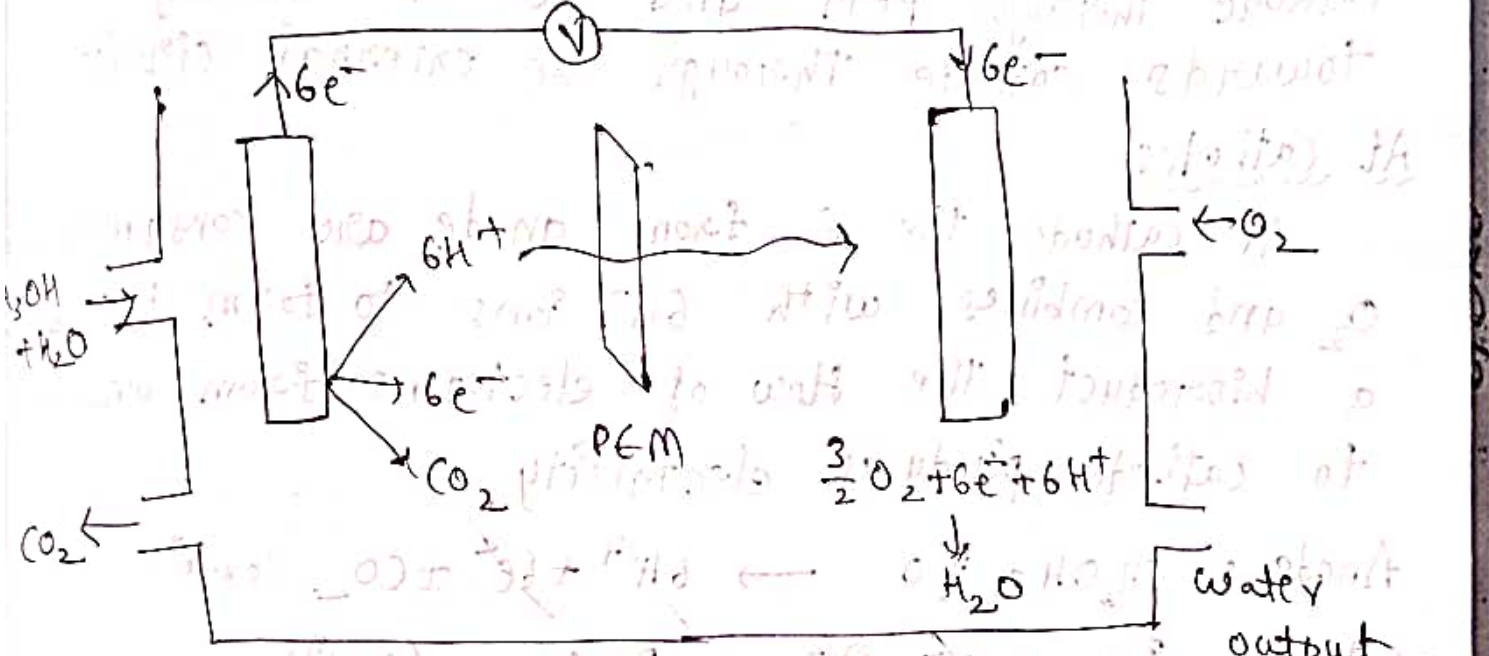
At cathode : $O_2 + 4e^- + 4H^+ \longrightarrow 2H_2O$ (redn).

$$2H_2 + O_2 \longrightarrow 2H_2O + \text{electricity}$$

). Explain the process of methanol-O_2 fuel cell.

Components of methanol-O_2 Fuel cell:-

* Fuel : $CH_3OH + H_2O$
* Oxident : O_2
* Anode porous electrode : Composed of Pt catalyst
* Cathode porous electrode : Composed of Pt catalyst.
* Electrolyte : KOH solution
* PEM : Proton Exchange Membrane.



Construction:-

The anode porous electrode and cathode porous electrode are connected to voltmeter by Cu wire and the electrodes are dipped in KOH solution. The PEM (proton Exchange Membrane) is placed b/w the electrodes which allows only H+ ions

Working :-

Methanol and water is passed through the anode porous electrode and oxident (O_2) is passed through the cathode porous electrode from the outside of the cell.

At anode :-

Methanol and water is dissociated as $6H^+$ and $6e^-$ untill the libration of CO_2 as final product the $6H^+$ ions are moving towards the cathode through PEM and $6e^-$ are moving towards cathode Through the external circuit.

At cathode :-

At cathode the e^- from anode are consumed by O_2 and combines with $6H^+$ ions to form H_2O as a biproduct, the flow of electrons from anode to cathode produces electricity.

Anode : $CH_3OH + H_2O \longrightarrow 6H^+ + 6e^- + CO_2$ (oxydn)

Cathode : $\frac{3}{2}O_2 + 6e^- + 6H^+ \rightarrow 3H_2O$ (redn)

$$CH_3OH + \frac{3}{2}O_2 \longrightarrow 2H_2O + CO_2 + \text{Electricity}.$$