3. Fuel Cells

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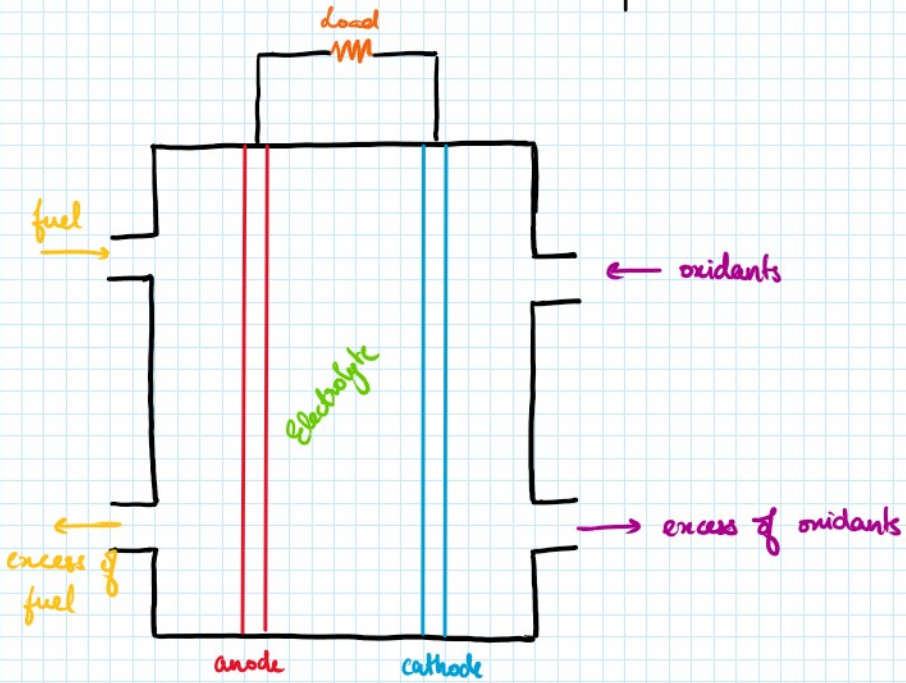
FUEL CELLS

DIFFERENCE BETWEEN BATTERIES & FUEL CELLS

BATTERIES	FUEL CELLS
CC ⟶ EE	Fuel energy ⟶ EE
• Storage of chemical energy	• Continuous supplying of fuel
• Storage is easier	• Storage is difficult
• Not eco-friendly	• Eco-friendly



Fuel | Anode | Electrolyte | Cathode | Oxidant

Fuel: H_2, CO, CH_3-OH, C_2H_5-OH ... etc.

Oxidant: O_2, halogens ... etc.

Anode: Fuel ⟶ Oxidised product + ne^-

Cathode: Oxidant + ne^- ⟶ Reduced product

Fuel + oxidant ⟶ Oxidised product + reduced product

ADVANTAGES

APPLICATIONS

ADVANTAGES

- Eco-friendly
- Silent operation
- High efficiency

APPLICATIONS

- Space applications
- Commercial vehicles

EFFICIENCY

$$\eta = \frac{\Delta G}{\Delta H} \times 100$$

$$\Delta G = -nEF$$

Values of n for different fuel cells

FUEL CELL	n VALUE
$H_2 - O_2$	2
CH_3-OH, O_2	6
CO, O_2	2

TYPES OF FUEL CELL

Fuel Cell	Fuel	Oxidant	Temp
① H_2-O_2 alkaline fuel cell	H_2	O_2	100°C
② Phosphoric acid fuel cell	H_2	O_2	160-220°C
③ Molten carbonate fuel cell	CO/H_2	O_2	600-650°C
④ Polymer membrane fuel cell	CH_3-OH	O_2	60-90°C
⑤ Solid oxide fuel cell	CO	O_2	650-1000°C

H_2-O_2 ALKALINE FUEL CELL

Fuel = H_2 Oxidant = O_2 Temperature = 100°C

- Low temperature fuel cell
- O_2 reduction faster in alkaline medium
- Using non-noble metal catalyst

Anode: Porous carbon with Pt → electrode material

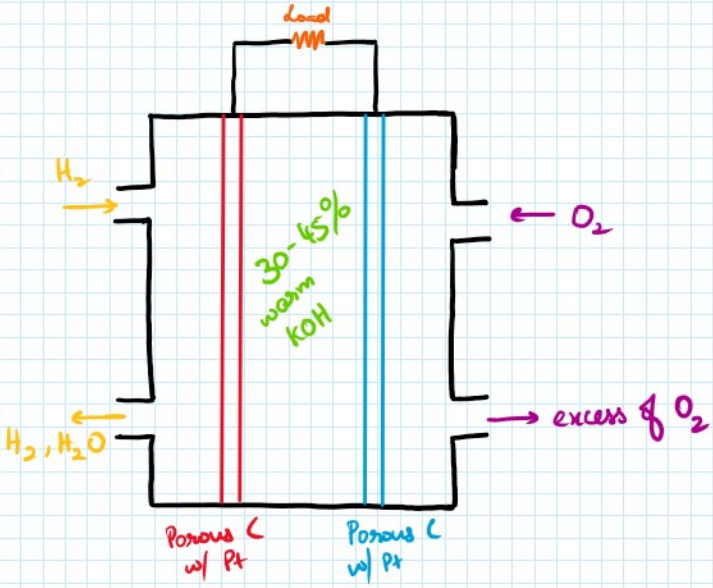
Cathode: Porous carbon with Ag → electrode material

Electrolyte: 30-45% warm KOH

Cathode: Porous carbon with Ag

Electrolyte: 30-45% warm KOH

H_2 | Porous carbon with Pt | 30-45% warm KOH | Porous carbon with Pt | O_2



EQUATIONS

Anode: $H_2 \longrightarrow 2H^+ + 2e^-$

$2H^+ + 2OH^- \longrightarrow 2H_2O$

$H_2 + 2OH^- \longrightarrow 2H_2O + 2e^-$

Cathode: $H_2O + \frac{1}{2}O_2 + 2e^- \longrightarrow 2OH^-$

Total: $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

ADVANTAGES

- High efficiency
- Silent operation
- Eco-friendly

APPLICATIONS

- Space application
- Electrical vehicles

DISADVANTAGE

- CO_2 effect

PHOSPHORIC ACID FUEL CELL

(H_2-O_2)

Fuel: H_2

Oxidant: O_2

Temperature: 160°C - 220°C

Electrolyte: Conc. phosphoric acid

ADVANTAGES

- High efficiency (pure H_2)

DISADVANTAGES

- Impure fuel w/ S, CO

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Poisons Pt and makes it unreactive → CHECK

MOLTEN CARBONATE FUEL CELL

[H_2 (or eg- O_2

MOLTEN CARBONATE FUEL CELL

[H_2 (or) CO - O_2]

Fuel: H_2 (or) CO Electrolyte: $LiAlO_2 + Li_2CO_3 + K_2CO_3$ (mixture)

Oxidant: O_2

Temperature: 600°C - 650°C

ADVANTAGE	DISADVANTAGE
• No expensive catalyst	• Slow start temp

POLYMER MEMBRANE FUEL CELL

[CH_3-OH] - O_2

Electrolyte: Aquivion [OR] Nafion [OR] SPEEK → Polytetrasulphonic acid group → releases H^+ ions

SPEEK → Sulphonated PolyEther Ether Ketone

Fuel: CH_3OH → light weight; high energy density

Oxidant: O_2

Temperature: 60°C - 90°C

Low temperature

At low temp. (40°C - 50°C) SPEEK → water flooding

SPEEK → releases more H^+ ions

High temperature

At high temp. (100°C - 120°C) SPEEK → Dries up or cracks; water management is difficult

SPEEK →

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Does not release H^+ ions

SOLID OXIDE FUEL CELL

CO - O_2

Electrolyte: Ceramic material : YSZ ⟶ releases O^{2-} ions

Yitria Stabilised Zirconia

ZrO_2 doped with Y_2O_3

Temperature: 650°C - 1000°C

Fuel: CO

Oxidant: O_2