

Content	Alkaline fuel cell	Proton exchange membrane fuel cell	Molten Carbonate fuel cell	Direct methanol fuel cell
Introduction	<ul style="list-style-type: none"> It was the first fuel cell technologies developed by NASA in space program It is a low temperature fuel cell 	<ul style="list-style-type: none"> The hydrogen is split into two streams at the anode, such as positive hydrogen proton and negative electrons It is developed for transport applications as well as for stationary fuel cell applications and portable fuel cell applications 	<ul style="list-style-type: none"> It is a high temperature fuel cell It is considered as the second generation fuel cell 	<ul style="list-style-type: none"> It directly converts the chemical energy of liquid methanol into electrical energy Here, methanol acts as better substitute for hydrogen in fuel cell.
Construction				
1. Anode	Porous carbon electrode containing Ni/PT catalyst	Inert material which is coated either by platinum or similar type of noble metals	Porous carbon electrode containing Ni alloy (Ni-Gr or Ni-Al)	Bipolar plates of porous mixture of carbon supported platinum or platinum/ruthenium
2. Cathode	Porous carbon electrode containing Ni/PT catalyst	Inert material which is coated either by platinum or similar type of noble metals	Porous carbon electrode containing lithiated nickel oxide	Bipolar plates of porous mixture of carbon supported platinum or platinum/ruthenium
3. Electrolyte	Aqueous KOH	The electrolyte could be a semipermeable polymer membrane which is permeable to hydrogen ions but does not conduct electrons. The polymer electrolyte may be of fluoropolymer (i.e. poly [perfluorosulphonic acid]) or nafion	Liquid electrolyte that is, molten carbonate namely, LiClO_3 , K_2CO_3 & Na_2CO_3 contained in a chemically inert lithium Aluminium Oxide (LiAlO_2) ceramic matrix	Polymer electrolyte membrane (Nafion - a sulphonated teflon)
4. Fuel	Pure hydrogen gas	High purity hydrogen	H_2 gas obtained from natural gas, water gas shift reaction, coal gas etc, through internal reforming	Methanol

5. Oxidant

AFC

Oxygen gas from air

PEMFC

Oxygen

MCFC

O_2 along with CO_2
This is CO_2 sequestered
from industrial fuel
gas can also be used

DMFC

O_2 gas

6. Condition

Operating at low temperature ($70^\circ C$)

$<100^\circ C$

$50 - 85^\circ C$

High operating temperature $\approx 650^\circ C$

7. Efficiency

60 - 70 %

50 - 60 %

50 - 60 %

45 - 50 %

8. Voltage

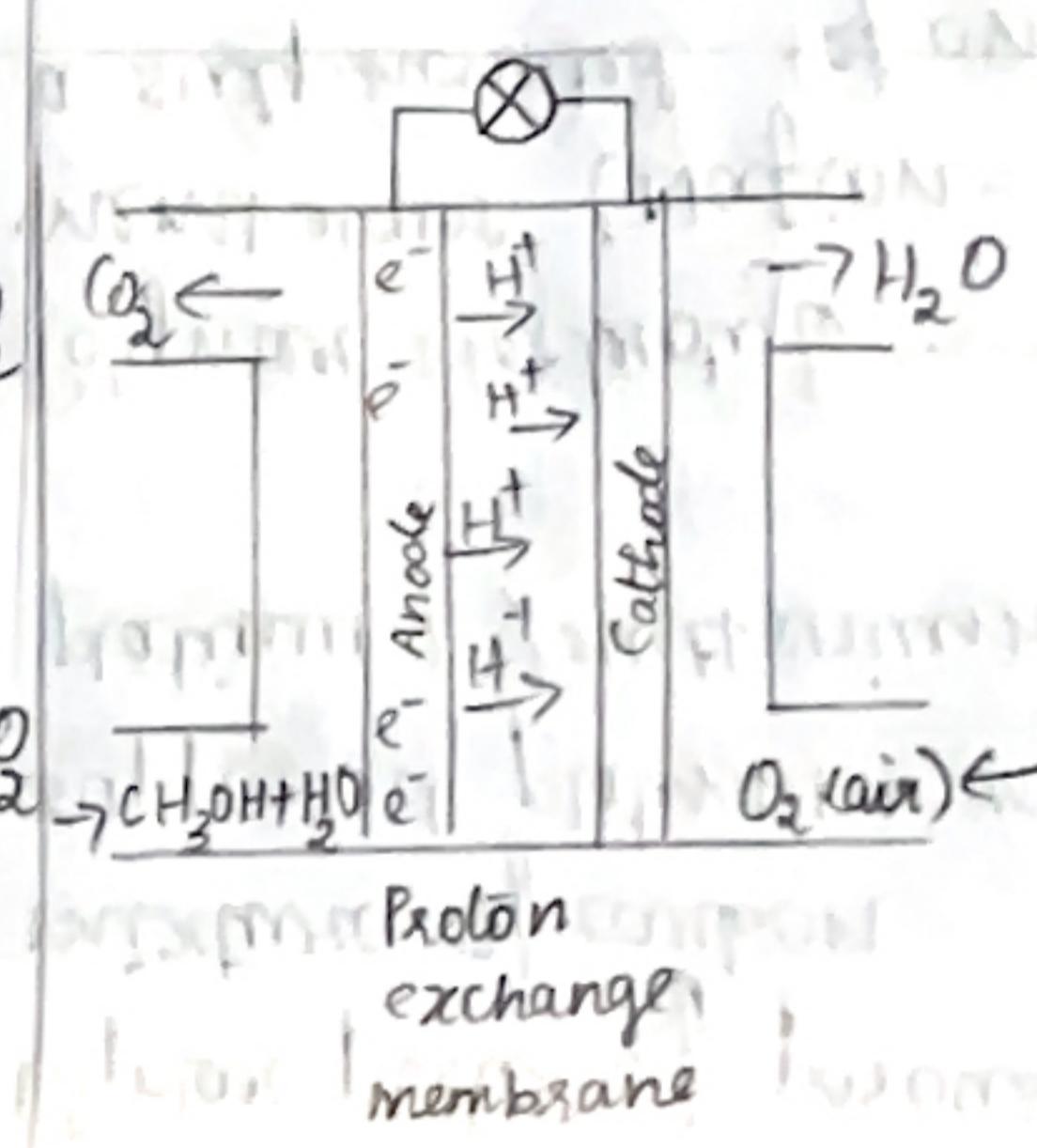
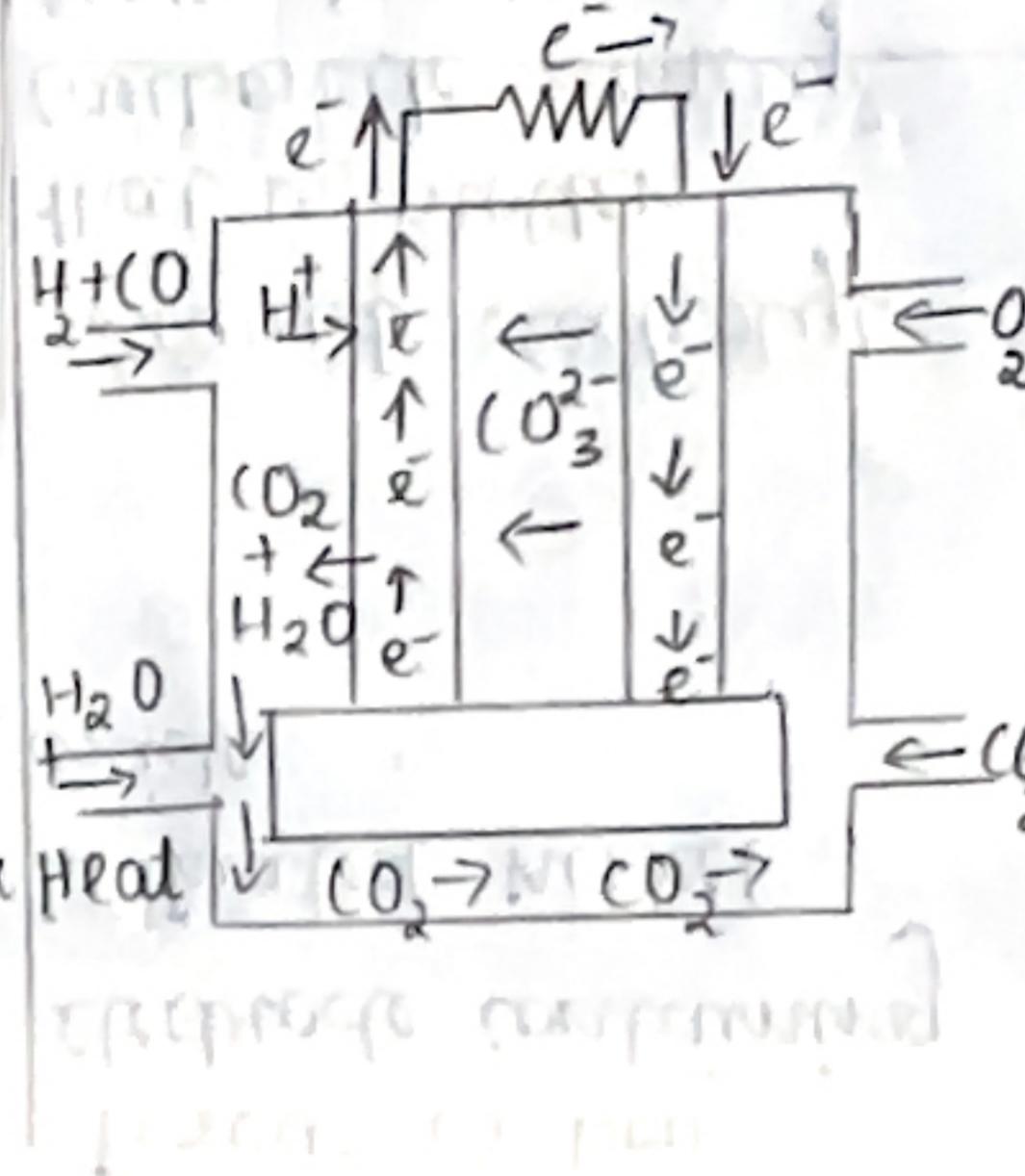
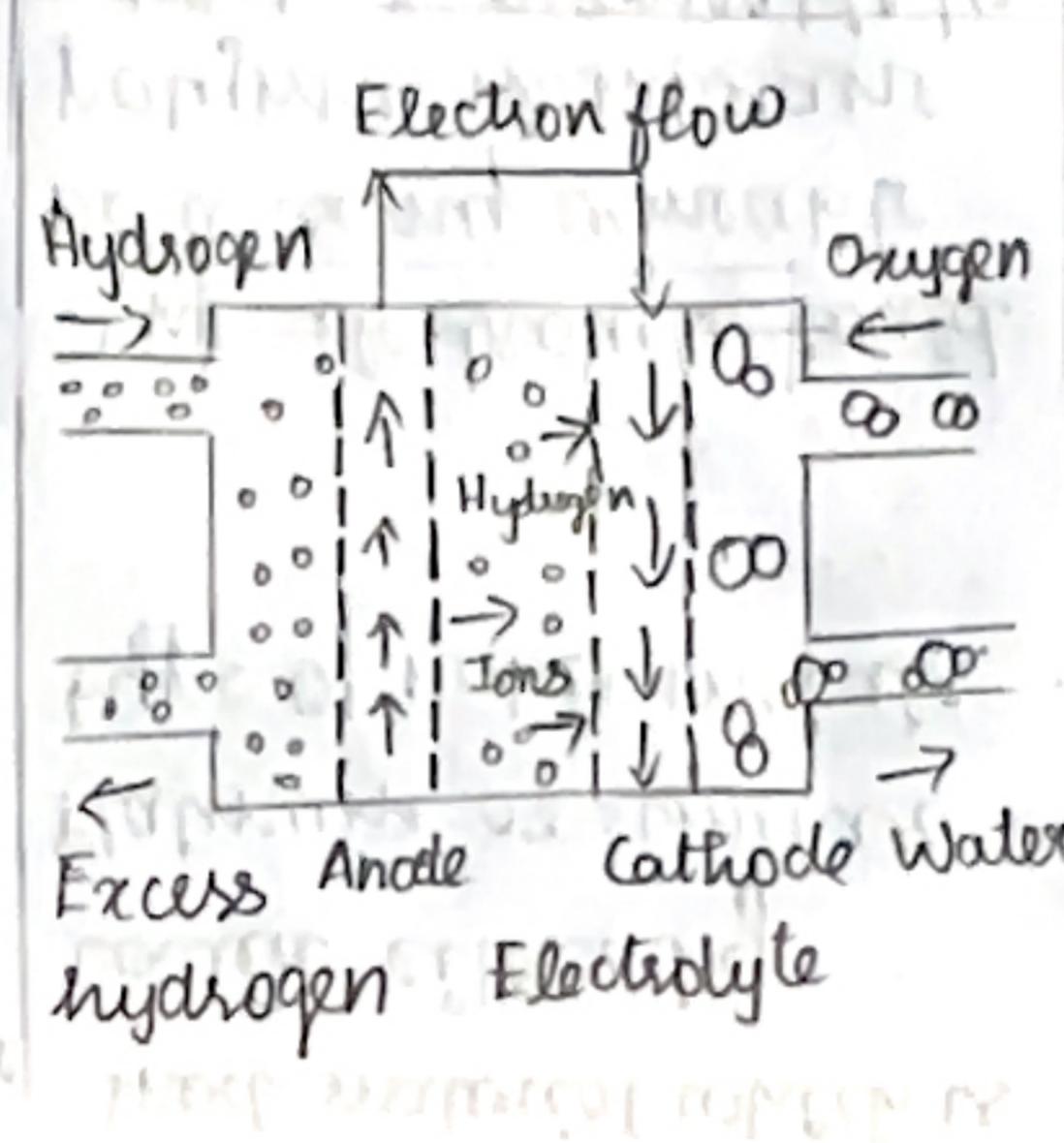
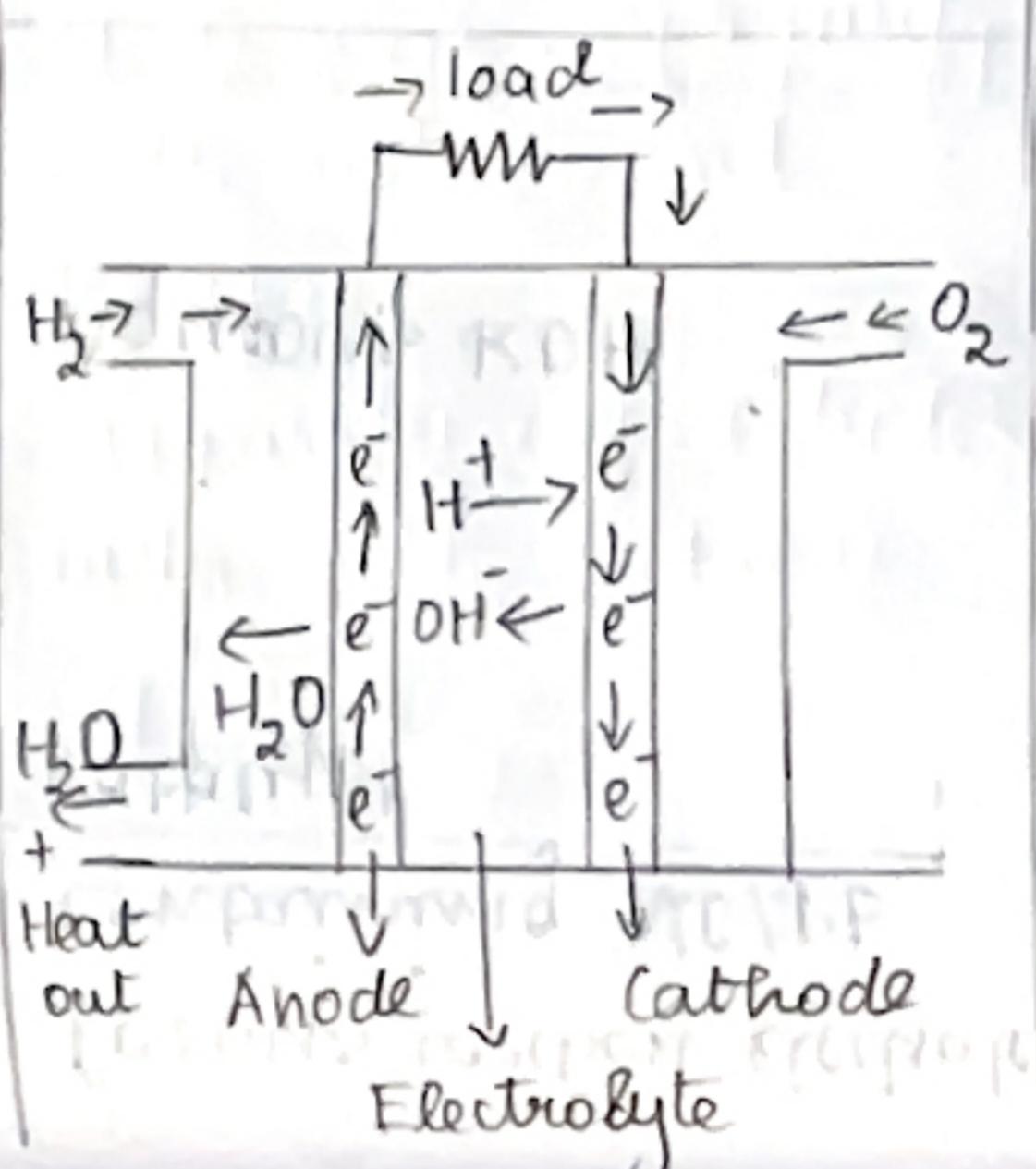
0.5 - 0.9 V

0.7 V

$\approx 1.5 V$

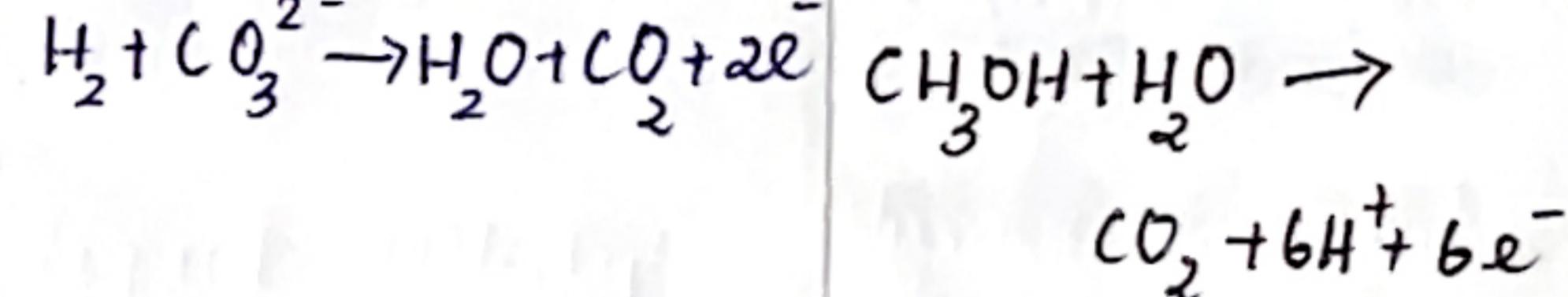
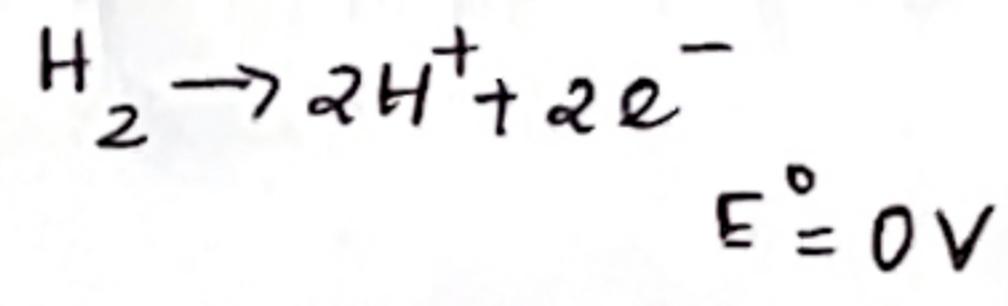
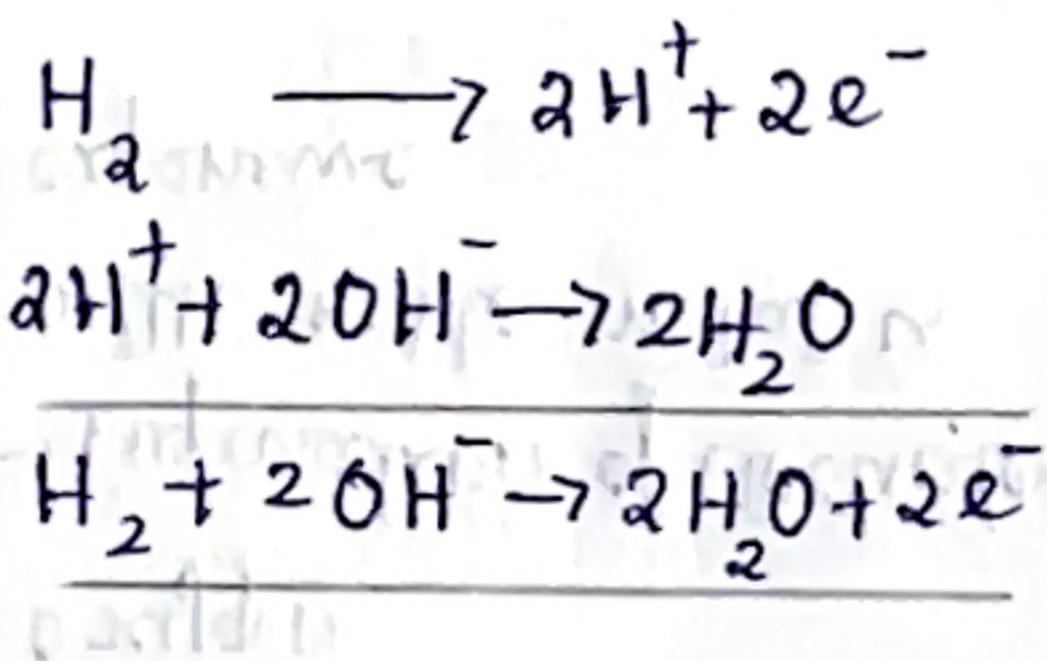
1.21 V

Diagram

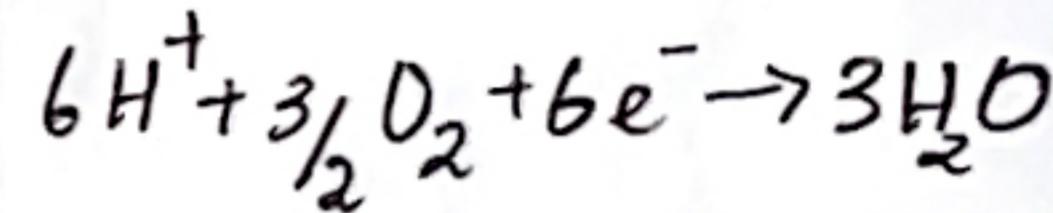
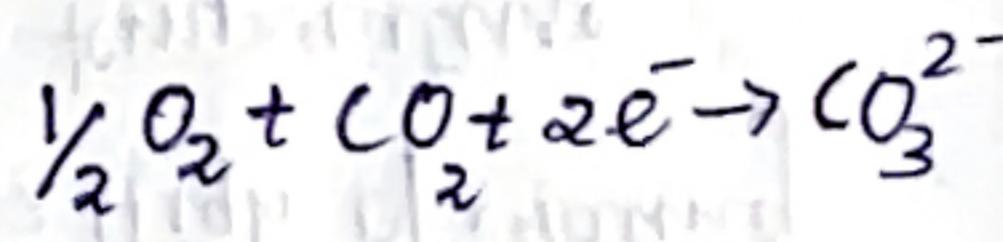
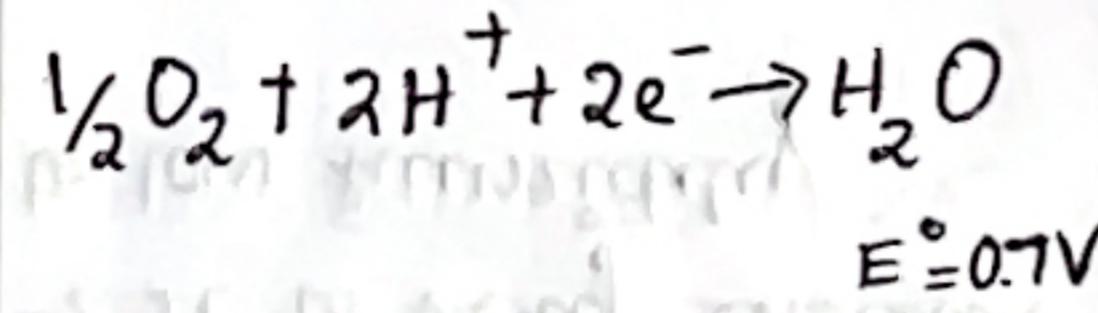
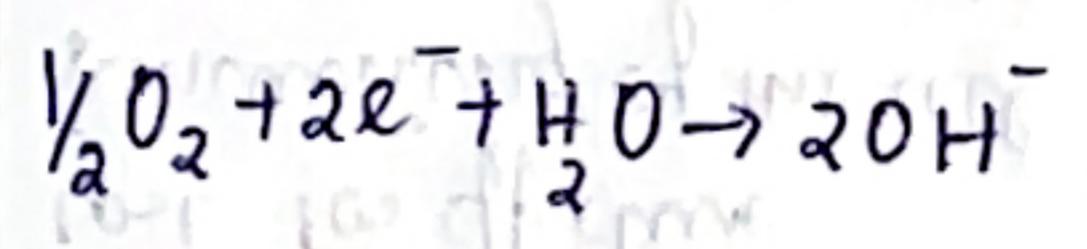


Working cell reaction

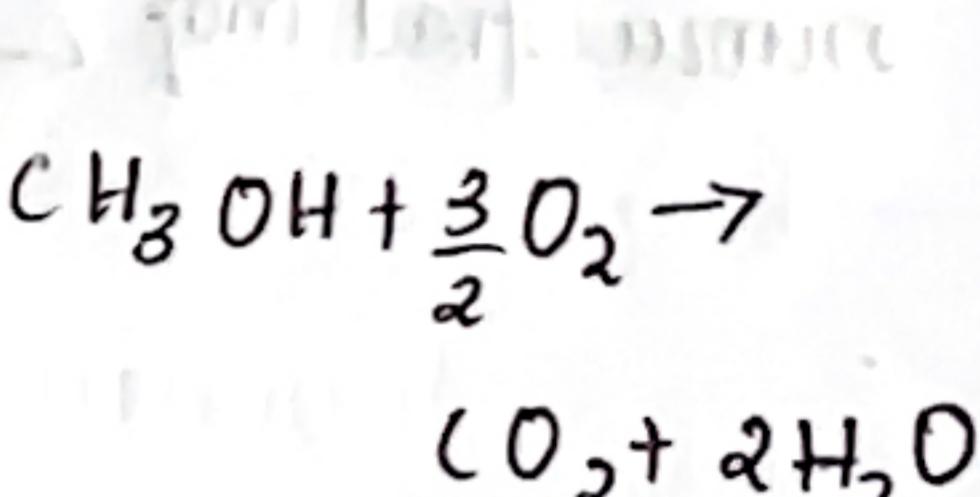
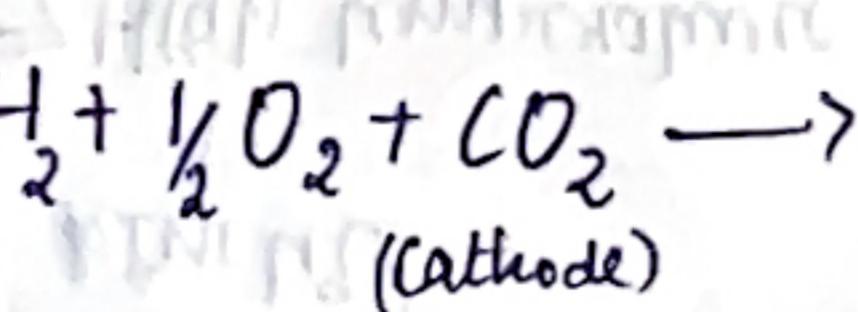
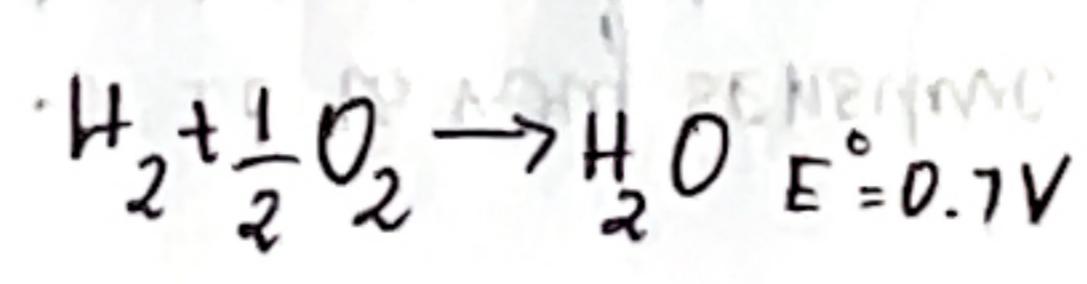
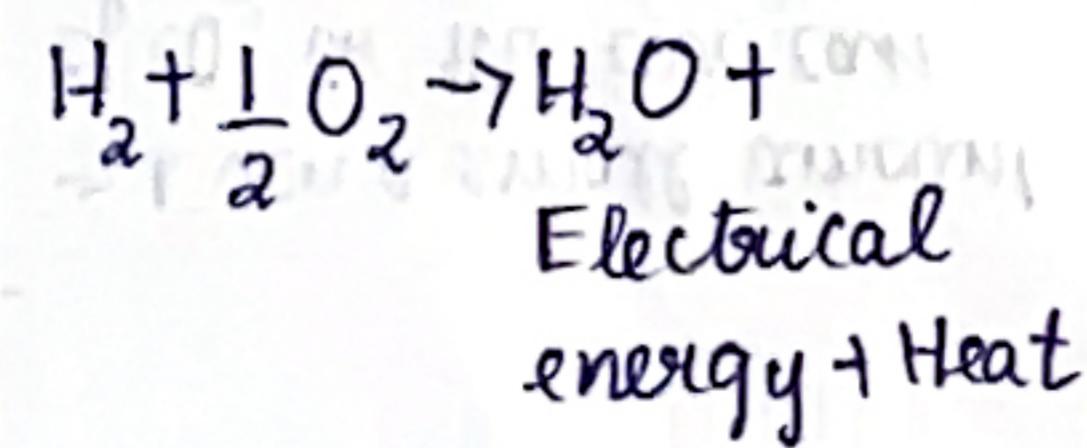
At anode:



At cathode



Overall reaction



(Anode)

- Alkaline group
- Protonic
- Absorbs up heat

- High temperature
- Particulate
- If absorption of heat
- 2nd step of heat

- 2nd step of
- 3rd step of heat

	AFC	PEMFC	MCFC	DMFC
Advantage	<ul style="list-style-type: none"> → Operates at low temperature → Simple design 	<ul style="list-style-type: none"> → It operates at low temperature → Their reaction starts quickly 	<ul style="list-style-type: none"> → They are more resistant to impurities than any other fuel cell due to internal reforming → Have fast reaction kinetics 	<ul style="list-style-type: none"> → Low cost → Simplicity of design.
Disadvantage	<ul style="list-style-type: none"> → Even a small amount of CO_2 in the air can affect the cell's life time hence, further adding cost. For effective functioning of the cell it is necessary to purify both hydrogen and oxygen → Preparation of electrodes with noble metal is expensive. 	<ul style="list-style-type: none"> → It is very sensitive to CO and sulphur poisoning → It is very sensitive to low humidity 	<ul style="list-style-type: none"> → High temperature accelerates the corrosion → High operating temperature decreases cell's life 	<ul style="list-style-type: none"> → Low performance by methanol crossover → CO poisoning
Applications	<ul style="list-style-type: none"> → Provides drinking water and electricity in space craft → NASA used AFC in space shuttle and in Apollo series mission 	<ul style="list-style-type: none"> Vehicles, small generators, domestic supply power stations 	<ul style="list-style-type: none"> Power plants, power supply in ships. 	<ul style="list-style-type: none"> → It is also used as backup for telecom systems. → It is used as portable charges for laptops, digital cameras, and mobile phones.