

UNIT - IV Alternative energy sources.

2 Marks.

1) what is the composition of natural gas?

Natural gas is at least 88% methane with the balance being higher weight hydrocarbons.

2) Define "Bio-Fuel" with any one example.

Biodiesel is oil from plants or animals used as an alternative to or blended with petroleum diesel in automobile and industrial fleets with diesel engine.

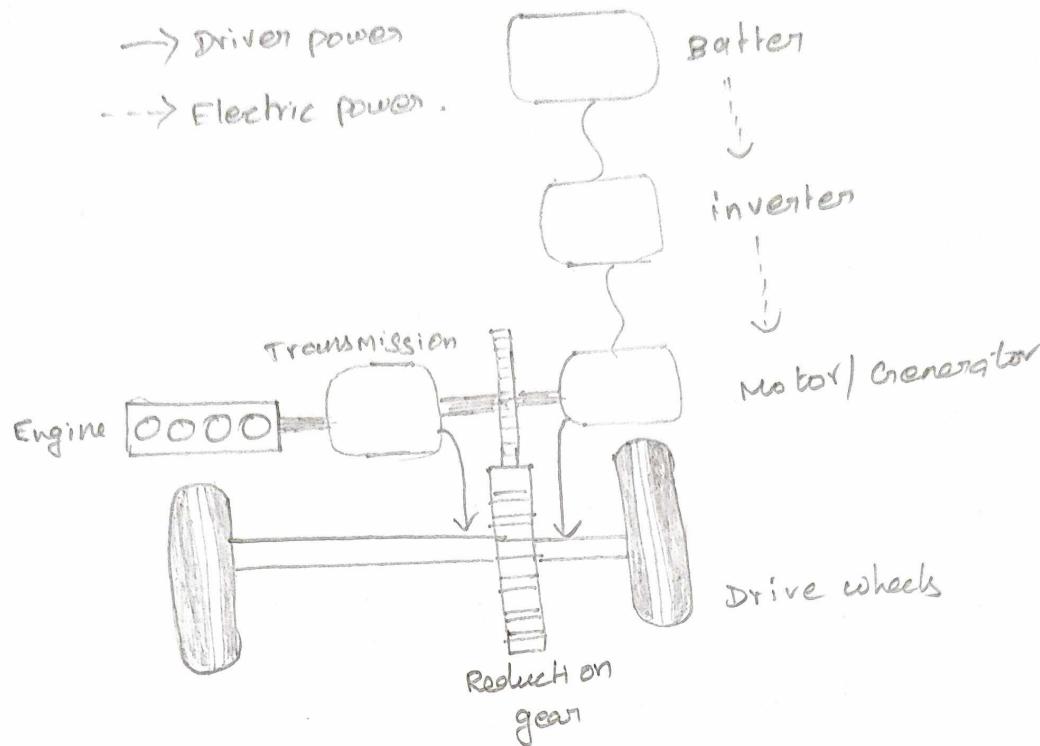
3) why alcohol is an alternate fuel for S.I. engine?

Alcohols can burn more completely and thus, increasing the potential combustion energy which will produce the most power. It also has the potential to reduce NO_x, CO, HC and particulates when they are used in SI engine.

4) List any two methods of hydrogen production?

1. Steam methane reforming of natural gas
2. partial oxidation
3. Autothermal reforming
4. Electrolysis of water.

5) Sketch the layout of a parallel - configure electric vehicle:



6) Define a hybrid vehicle?

The vehicle which is using more than one source of energy to run is called hybrid vehicle. Hybrid means that it is mixed together from two things. Usually, it refers to plants or animals that are breed from different dissimilar parents.

7) Mention the classification of Hybrid vehicles?

1. series configured vehicle
2. parallel configured vehicle
3. series - parallel configured vehicle
4. complex configured vehicle.

8) Enumerate the limitations of electric vehicle?

1. Initial torque is less
 2. It is expensive
 3. Frequent recharging of battery is needed and battery charging needs more time.
 4. The performance is poor.
- 9) What is the working principle of fuel cell?
- A fuel cell produces electricity directly from the reaction between hydrogen (derived from a hydrogen-containing fuel or produced from the electrolysis of water) and oxygen from air. In a fuel cell, the fuel is also oxidized but the resulting energy takes in the form of electricity. When powered by pure hydrogen, the only by-products of the reaction are heat and water.

10) Mention any four types of fuel cells?

- (a) Hydrogen-oxygen fuel cell
- (b) polymer electrolyte membrane (PEM) fuel cell
- (c) Alkaline fuel cell
- (d) phosphoric acid fuel cell
- (e) molten carbonate fuel cell
- (f) solid oxide fuel cell.

i) with aid of a simple sketch, discuss about the working of a solid oxide fuel cell.

* solid oxide fuel cell (SOFCs) use hard and non-porous ceramic compound as the electrolyte. For example, zirconium oxide containing a small amount of other oxide to stabilize the crystal structure has been used as an electrode.

* the material is able to conduct O⁻ ions at high temperature.

* the negative electrode is made of porous nickel and positive electrode employs metal oxide e.g. indium oxide.

* since the electrolyte is a solid, cells do not have to be constructed in the plate similar to the configuration of typical other fuel cell type.

* the efficiency of SOFCs is expected around 50-60% in converting fuel to electricity.

* These cells can be used where the system wants to capture and utilize the system's waste heat (co-generations)

* The overall fuel efficiency is around 80-85%
 Figure 5.38 illustrate the construction details and
 electron flow of the SOFC

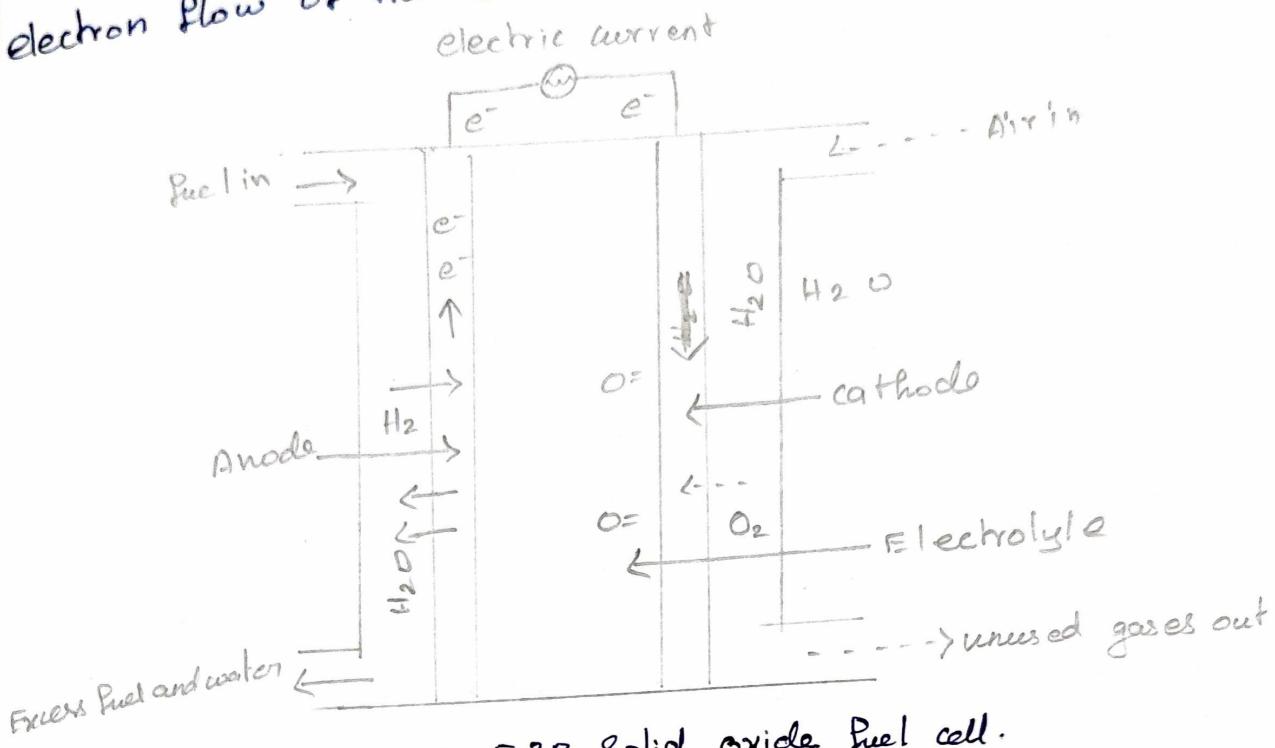


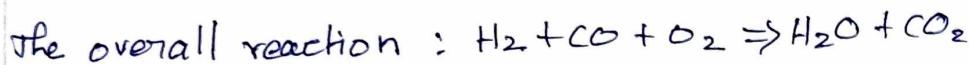
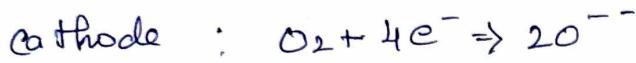
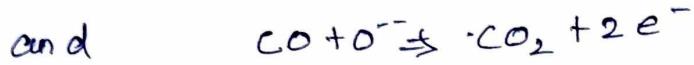
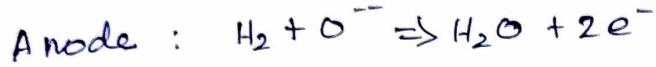
Figure 5.38 Solid oxide fuel cell.

* SOFCs operate at high temperature range of 600-1,000°C. High temperature operation removes the need for precious metal catalyst thereby reducing its cost.

* It also allows SOFCs to reform fuels internally which enables the use of a variety of fuels and it reduces the cost associated with adding a reformer to the system. The output voltage at full load is about 0.63V

* At the fuel electrode H₂ and CO react with O²⁻ ions present in the electrolyte to produce H₂O and CO₂. The two electrons released per ion flow through external

path to constitute load current. Similar to metal oxide fuel cell, the heat of discharge can be utilized as process heat. The reactions at the electrodes are



* SOFCs are also the most sulphur-resistant fuel cell type. In addition, they are not poisoned by carbon monoxide (CO) which can even be used as fuel. It allows SOFCs to gases made from coal

Q) Enumerate the advantages and disadvantage of using alcohol as a fuel:

Advantages of using ethanol or alcohol as a fuel:-

- * It can be obtained from a number of sources both natural and manufactured
- * It is high octane fuel with anti-knock index numbers of over 100. Engines using high-octane fuel can run more efficiently by using higher compression ratio.
- * Increased octane in gasoline reduces engine "knock".
- * It has low sulfur content in the fuel.

* Ethanol reduces the country's dependence on imported oil in lowering the trade deficit.

* Farmers see an increased demand for grain which helps to stabilize the prices.

* CO emissions are reduced (more than 25%) and lead and other cancer causing agents are removed from gasoline. Thus, quality of the environment improves.

* Ethanol blends such as E-10 unleaded can be used in virtually all gas engines without any engine or mechanical modifications.

* Ethanol is a safe replacement for toxic octane enhancers in gasoline such as benzene, toluene and xylene.

* Ethanol reduces greenhouse gas emission because it is produced from renewable agricultural feed stocks.

Disadvantages of using ethanol or alcohol as a fuel:-

* More storage capacity of fuel tank is required due to low energy content of the alcohol which means almost twice the amount of gasoline must

be burned to give the same energy input to the gas engine.

* Engines run on ethanol may give starting problems when the air is cool.

* Alcohol contains oxygen and thus, it requires less air for stoichiometric combustion. More fuel can be burned with the same amount of air.

* More aldehydes are present in exhaust. If

as much alcohol fuel was consumed as gasoline, aldehyde emissions could be a serious exhaust pollution problem.

* Alcohol is much more corrosive than gasoline

on many metals. It puts restrictions on the design and

manufacturing of engines to be used with this fuel.

* poor ignition characteristic in general

* Alcohols have almost invisible flame

which is dangerous when handling fuel.

* Danger of storage tank flammability

due to low vapour pressure. Air can leak into storage tanks and create a combustible mixture.

* Vapour lock in fuel delivery systems

may happen frequently.

3) Discuss about the challenges faced in production and storage of hydrogen gas?

challenges for Hydrogen fuel:

- Hydrogen as a fuel source has a number of obstacles and challenges that currently limit its viability as a serious replacement for fossil fuel.
- Hydrogen presents unique challenges because of its high diffusivity, extremely low density as a gas and liquid and broad flammability range relative to hydrocarbons and low-molecular-weight alcohols.
- These unique properties present special cost and safety obstacles at every step from manufacture to distribution to, ultimately on-board vehicle storage.

(a) challenges in production of hydrogen:

- A key problem with the hydrogen is that pollution-free sources of hydrogen are unlikely to be practical and affordable for decades.
- Indeed, even the pollution-generating means of making hydrogen are currently too expensive and inefficient to substitute for oil.

* natural gas (methane or CH₄) is the source of 95% of hydrogen production. The overall energy efficiency of the steam methane reforming process (the ratio of the energy in the hydrogen output to the energy in the natural gas fuel input) is about 54%.

* the cost of producing and delivering hydrogen from natural gas or producing hydrogen onsite at a local filling station is more than three times the current untaxed price of gasoline.

* therefore, it is too expensive even though it produces no greenhouse gases.

* challenges in storage and transportation of hydrogen:-

(a) one of the main challenges to hydrogen is the issue of storing it. If using it as a direct fuel to a vehicle, it must be stored on board and must be pressurized (in some cases to five or ten thousand psi) or liquefied to have an appropriate driving range.

* Another critical issue is the form of hydrogen being shipped. Hydrogen can be transported as a pressurized gas or a cryogenic liquid.

* It can also be combined in an absorbing metallic alloy matrix or adsorbed on or in a substrate or transported in a chemical precursor form such as

lithium, sodium metal or chemical hydrides.

- * Tanker trucks carrying liquefied hydrogen are used to deliver hydrogen today but they make little sense in a hydrogen economy because of liquefaction's high energy cost.

- * Pipelines are also used for delivering hydrogen today. Interstate pipelines are estimated to cost \$1 million per miles or more.

- * Current technology does not provide a reasonable cost and volume for transportation or stationary application.

4) Explain the engine modification required for using LPG in SI and CI engine?

Engine modifications for LPG:

- * Both the SI and CI engine can be modified easily to run on LPG. Many LPG or propane vehicles are converted into gasoline vehicles by using relatively inexpensive conversion kits. This conversion kit includes the following.

- a regulator/vaporizer that change liquid propane to a gaseous form

→ an air / fuel mixer that meters and mixes the fuel with filtered intake air before the mixture is drawn into the engine's combustion chamber.

→ a closed-loop feedback circuitry that continually monitors the oxygen content of the exhaust and adjusts the air/fuel ratio as necessary.

* LPG vehicles additionally require a special fuel tank is strong enough to withstand LPG storage pressure of about 10 bar.

* As LPG is stored in liquid form under high pressure, it is needed to convert it into vaporized form before drawn into the combustion chamber.

* As engine technology for LPG vehicles is similar to that for natural gas vehicles, with the exception that LPG is not commonly used in dual-fuel diesel applications due to its relatively poor knock resistance.

For SI engine, there are the following two types of LPG engines primarily used-

(a) LPG which is stored in composite vessel at high pressure approximately at 10-20 bar. Supply to the engine is controlled by a regulator or vaporizer which converts LPG to a vapor.

* The vapour is fed to a mixer located near the intake manifold where it is metered and mixed with filtered air before being drawn into the combustion chamber where it is burned to produce power similar to gasoline.

(b) LPG Fueled direct injection SI engine. It is especially developed in order to improve the exhaust emission quality while maintaining high thermal efficiency comparable to a conventional engine.

* In-cylinder direct injection engines developed recently worldwide utilized the stratified charge formation technique at low load whereas at high load, a close-to-homogeneous charge is formed.

* Thus the compared to a conventional port injection engine, a significant improvement of fuel consumption, power can be achieved and these systems have proven to be reliable in terms of engine durability and cold starting.

* Diesel engines cannot be run by using only LPG as a fuel. A dual fuel supply system can be used to economically convert the conventional diesel engines into LPG/diesel dual fuelled engines.

* These engines are capable of using either single diesel fuel or dual mode of diesel + LPG depending upon the requirement.

* The modifications required for this type of engines are LPG storage tank, regulating valve, reducer-evaporate, diesel-LPG mixed and cooling line arrangement.

* In addition on this, in-cylinder flow is to be made more turbulent by a suitable piston cavity modification.

5) with an indicative sketch, discuss about the working of a Polymer electrolyte membrane Fuel cell.

* Polymer Electrolyte membrane (PEM) Fuel cells also called proton exchange membrane fuel cells deliver high power density and offer the advantages of low weight and volume when compared to other fuel cells.

* PEM Fuel cell use a solid polymer as an electrolyte and porous carbon electrodes containing a platinum catalyst.

* They need only hydrogen, oxygen from air and coater to operate.

- * It does not require corrosive fluids similar to some other fuel cells.
- * They are typically fuelled with pure hydrogen supplied from storage tanks or on board reformers.

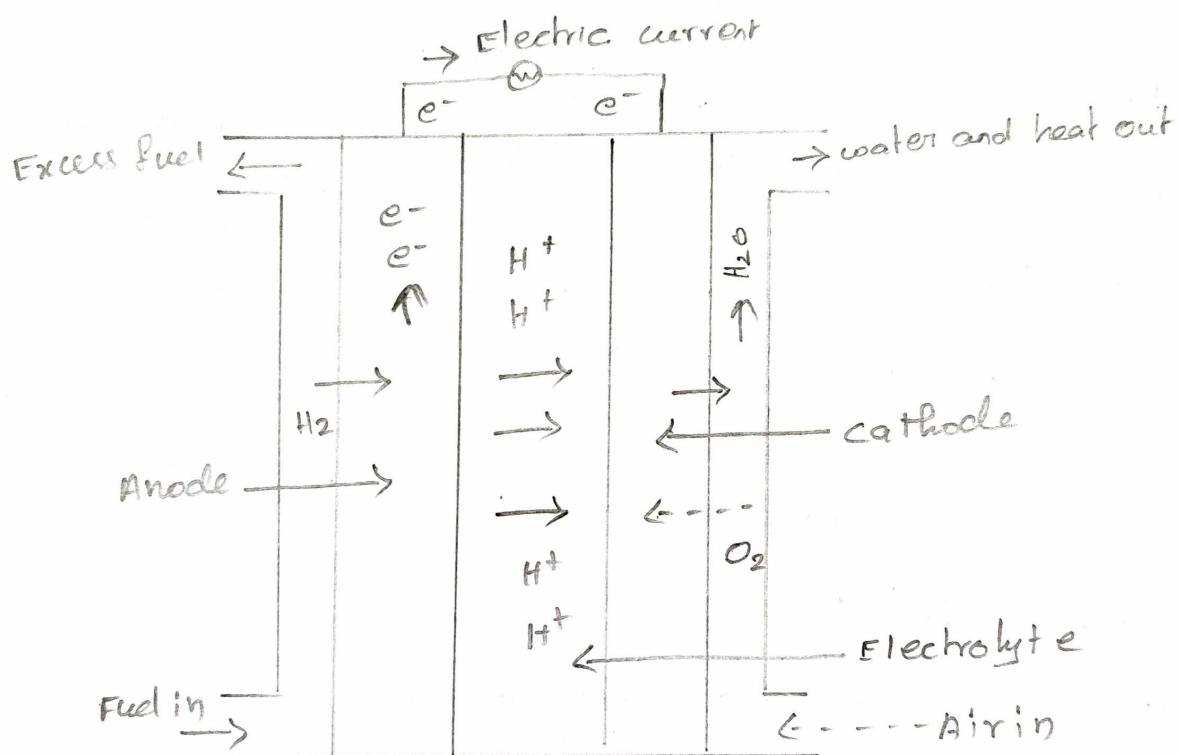


Figure 5.34 Polymer electrolyte membrane fuel cell

- * Polymer electrolyte membrane fuel cells operate at relatively low temperature around $80^\circ C$.
- * Low temperature operation allow them to start quickly (less warm-up time) and it leads to less wear

on system components thereby resulting better durability

* However, it requires a noble-metal catalyst

(platinum) which is used to ~~separ~~ separate hydrogen electrons and protons.

* It is added with the system cost.

* The platinum catalyst is also extremely sensitive to CO poisoning making it ~~not~~ necessary to employ an additional reactor to reduce CO in the fuel gas if hydrogen is derived from an alcohol or hydrocarbon fuel.

* It is also added with the cost.

* PEM fuel cells are primarily used for the transport applications and some stationary application.

Q) what are the advantages and Limitations of electric vehicle?

Advantages or merits of Electric vehicles:-

* EVs are Zero emission vehicles. It means, they produce no tailpipe or evaporate emissions that contribute to air pollution and global warming (although electricity production is not pollution-free)

* The cost of electricity per kWhr usually

compares favorably to gasoline but it varies depending on location.



* More than 95% of the electricity used to charge EVs originates from domestic resources.

* So driving an EV reduces the nation's dependence on imported oil.

* EVs require less service because they do not need oil and they have no timing belts, water pumps, radiators, fuel injectors or tailpipes.

Advantages :-

1. There is no pollution due to emission.

i.e., zero emission

2. It ensures smooth operation i.e., vibration and noise is less.

3. cost of operation is less

4. Less maintenance is required

5. It is easy to start the vehicle

6. It takes up less space on the road. So, they help to reduce traffic congestion.

Limitations of Electric vehicles :-

- * most EVs today can only go about 250 kms before you need to plug and recharge their batteries
 - * they are not such as the energizer that keeps on going . B)
 - * But, 150 to 250 kms is plenty for most people who only drive for a short distance to and from work, to and from school or to do some shopping such as Ford.
 - * Some EVs with special batteries can go for a longer distance. The car that is made by a company in Massachusetts called Solecstra.
 - * It is called "Sunrise". In 1995, a Solecstra Sunrise sets a world record for going 100km on one charge.
 - * Electric vehicles are more expensive than gasoline cars but when more and more EVs are made the price of EVs should drop to the same cost as gasoline.
 - Summary of limitations of electric vehicles is given below:
- 1. It has less torque
- 2. It is more expensive
- 3. The performance is poor
- 4. Less variety of vehicles is available in the Market.

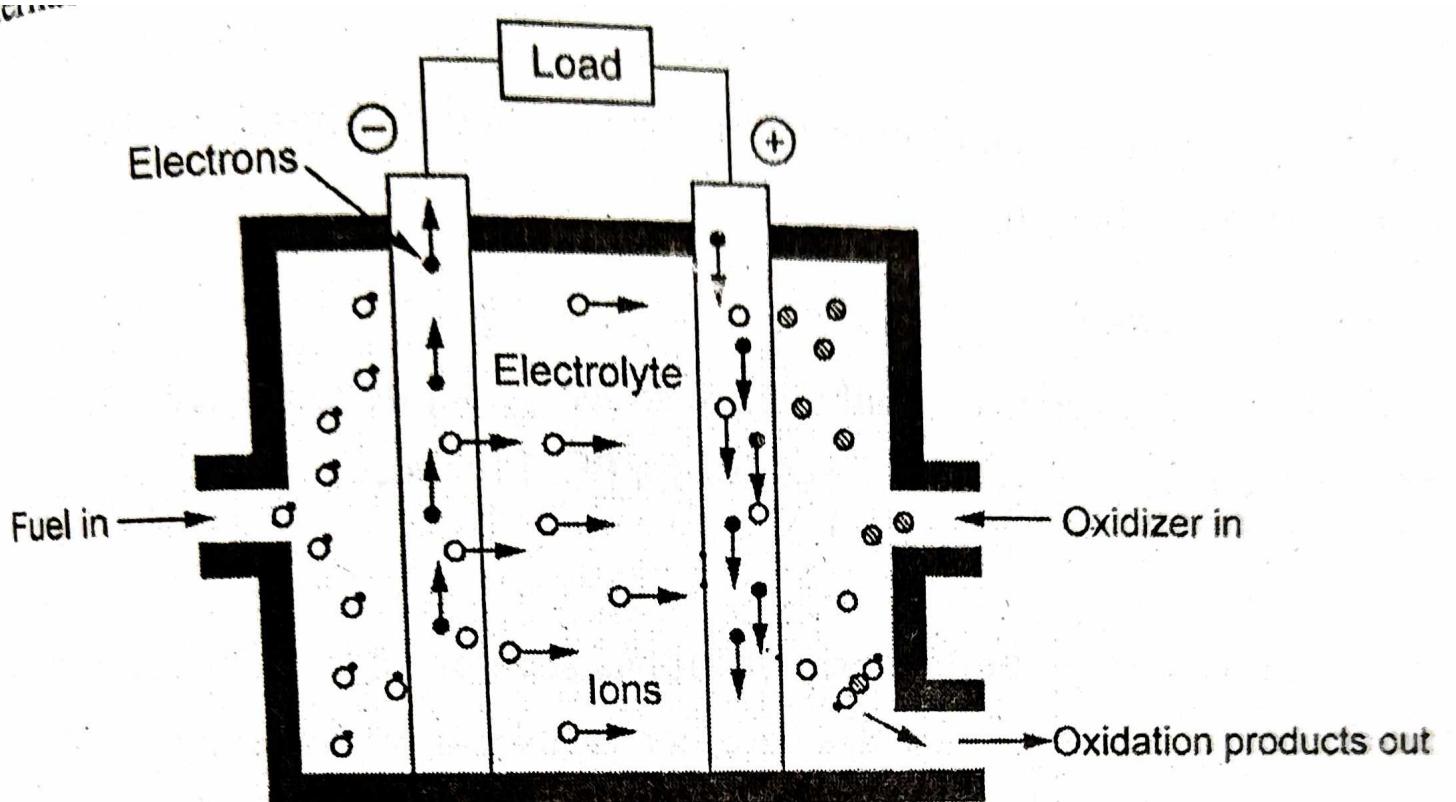


Figure 5.32 Schematic of a fuel cell

F) Explain the working principle, Merits and demerits of a fuel cell with schematic diagrams.

working principle of a fuel cell :

- * Fuel cell is an electrochemical device in which the chemical energy of a conventional fuel is directly converted into low voltage DC electrical energy.
- * One of the main advantages of such device is that cannot limitation on efficiency does not apply because the conversion can be carried out isothermally.
- * A fuel cell is frequently described as a primary battery in which the fuel and oxidizer are stored and fed to it as needed.
- * A fuel cell produces electricity directly from the reaction between hydrogen (derived from a hydrogen-containing fuel or produced from the electrolysis of water) and oxygen from air.
- * In a fuel cell, the liquid is oxidized but the resulting energy takes in the form of electricity when powered by pure hydrogen, by-products of the reaction are heat and water.

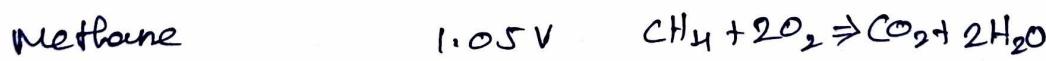
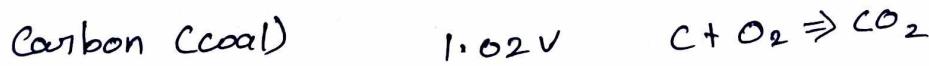
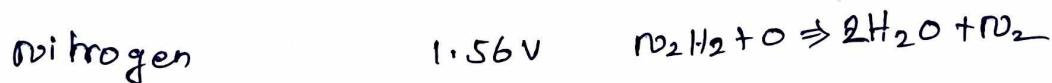
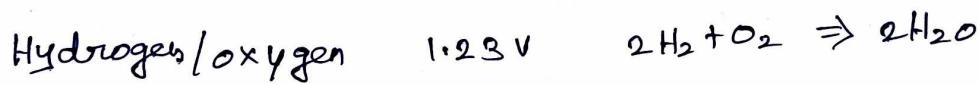
* The Figure 5.32 shows a schematic diagram of a fuel cell. The fuel gas diffuses through the anode and it is oxidized.

* Therefore, it releases electrons to the external circuit. The oxidized fuel diffuses through the cathode and it is reduced by electrons coming from anode by the way of external circuit.

* The fuel cell is a device which keeps the fuel molecules from mixing with the oxidizer molecules but it permits the transfer of electron by a metallic path that may contain a load.

* Hydrogen has so far given the most promising result, although cells consuming coal, oil or natural gas would be economically much more useful for large scale applications.

Some of the possible reactions are given by



Advantages of fuel cells:

- * Fuel cells eliminate pollution caused by burning fossil fuel as the only by-product is water
- * Fuel cells do not need conventional fuels such as oil or gas and can therefore eliminate economic dependence on politically unstable countries.
- * The maintenance of fuel cells is simple since there are few moving parts in the system.
- * Fuel cells use a variety of fuels such as renewable energy and clean fossil fuels.
- * Fuel cells can be responsive to changing electrical loads.

when they are getting refueled.

Disadvantages of fuel cells:-

- * Initial cost is high. Fuel cells are currently very expensive to produce since most units are hand-made.

- * Service life is low
 - * operations requires replenishable fuel supply
 - * Some fuel cells use expensive materials.
 - * The technology is not yet fully developed
- and few products are available.

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