

UNIT-5 Energy Sources and E waste Management

Fuel cells

Fuel cell:

It is a galvanic cell in which the electrical energy is directly derived by the combustion of chemical fuels supplied continuously or a **fuel cell** is an electrochemical conversion device. Like other electrochemical cells, the fuel cell has two electrodes and an electrolyte. The reaction occur in the fuel cell are represented as shown

Fuel / electrode / electrolyte / electrode / oxidation

Electrode reactions:

At anode, fuel under goes oxidation $\text{fuel} \rightarrow \text{oxidaton} + n e^{-1}$

At anode, the oxidant gets reduced $\text{oxidant} + n e^{-1} \rightarrow \text{reduction products}$

The electrons liberated from the oxidation process at the anode can perform useful work when they pass through the external circuit to the cathode.

Difference between fuel cell and conventional battery:

Fuel Cell	Battery
1. Fuel cell produces electrical energy continuously as long as the fuel and the oxidants are fed into the respective electrodes.	1. Battery produces electrical energy until the materials are present in the cell
2. Reactants are fed from outside to the electrode of the fuel cell	2. Reactants are the integral part of the construction of the cell
3. Fuel cell do not require recharging	3. Battery needs recharging.
4. High efficiency of production of electrical energy	4. Low efficiency of production of electrical energy.
5. Fuel cells need less attention.	5. Battery needs more attention.
6. Waste production in the fuel cell are harmless	6. Waste product in the battery may be harmful
7. Fuel cells do not store chemical energy.	7. Batteries store chemical energy.

Advantages of fuel cells:

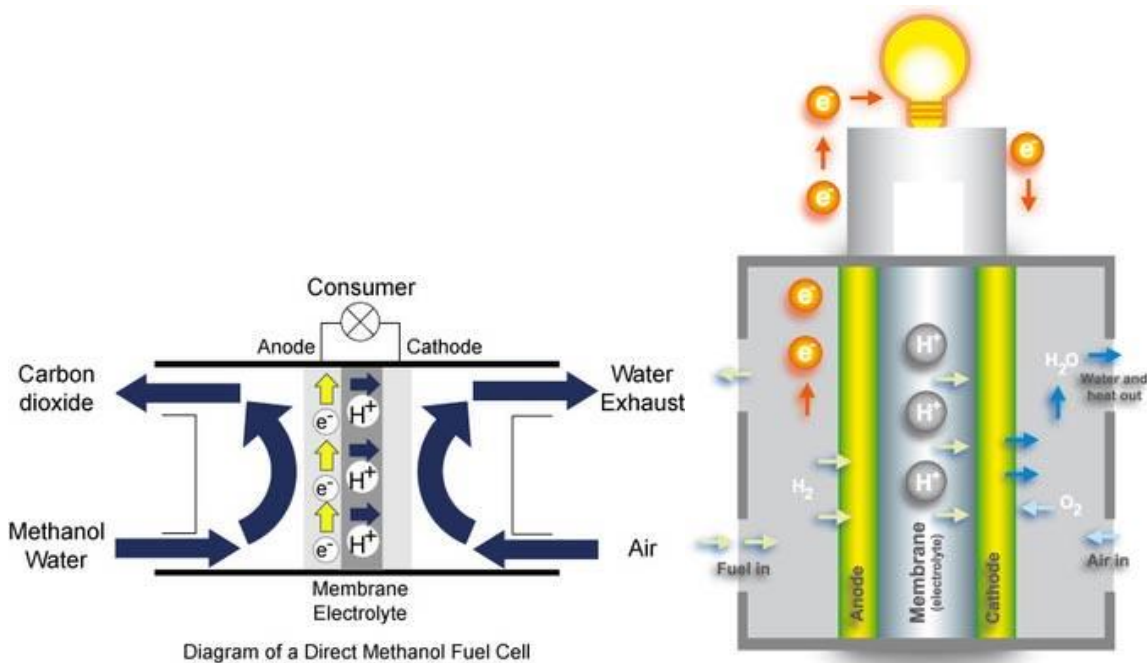
They produce continuous energy.

1. Power efficiency is high
2. They are eco friendly as the products of the overall reactions are not toxic and hence no environmental problems.
3. Silent operations
4. They produce direct current for long periods at low cost
5. Its produces harmless waste products
6. No need of charging

Methanol – Oxygen fuel cells:

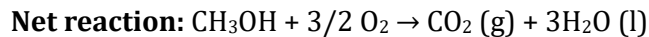
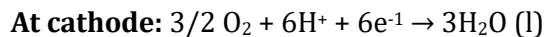
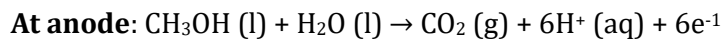
Methanol is one of the most electro active organic fuel in the low temperature range because

1. It has low carbon content.
2. It possesses a readily oxidisable OH group.
3. It has high solubility in aqueous solutions.



In this, the anode consists of a porous nickel sheet on which platinum – palladium catalyst is deposited and the cathode consists of silver impregnated porous nickel sheet. A membrane is inserted adjacent to the cathode on the electrode side. To minimize diffusion and as a result reduces the presence of methanol near cathode. The electrolyte containing methanol is circulated through the anode chamber. Pure oxygen or air is passed through the cathode chamber and sulphuric acid which acts as the electrolyte is placed in the central compartment.

Electrode reactions: The following reactions are take place at the electrodes.



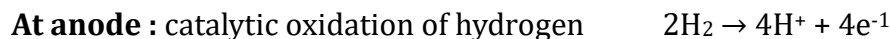
The potential of the cell is 1.20 V at 25°C.

Uses: It is used in the military applications and large scale power production.

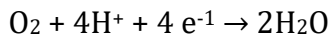
Polymer electrolyte fuel cells:

In this ion exchange membrane used as a solid electrolyte for ionic conduction between anode and cathode and also function as separator for the two reactants gases. The electrodes are made of from platinum block and noble metals are used as electro catalyst.

Electrode reactions:



At cathode: combining catalytically with oxygen and electron to form water.



Advantages: 1. No liquid electrolyte in the cells so it is corrosive free

2. Simple to fabricate

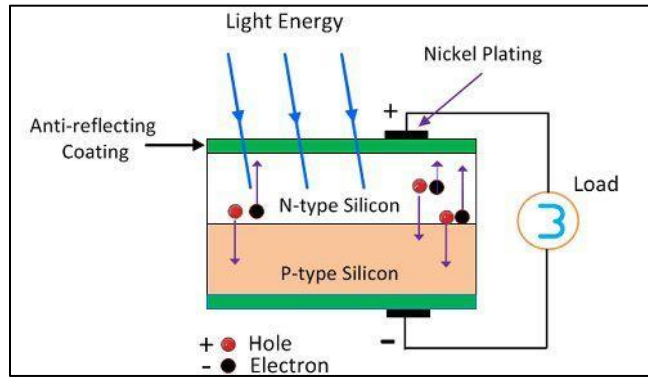
3. Able to with stand large pressure

4. Long life.

Photovoltaic Cells:

Photovoltaic cells are semiconductor device which convert solar energy into electrical energy. (Photovoltaic cell is based on the principle of photoelectric effect).

Construction and working of photovoltaic cells



A typical silicon photovoltaic cell is composed of a thin poly crystalline silicon wafer consisting of an ultra-thin layer of phosphorus doped. (n-type) silicon on top of boron doped (p-type) silicon. Hence a p-n junction is formed. A metallic grid forms one of the electrical current contacts of the diode and allows light to fall on the semiconductor between the grid lines as shown in Fig. An antireflective layer between the grid lines increases the amount of light transmitted to the semiconductor. The cell's other electrical contacts is formed by a metallic layer on the back of the solar cell. PV cell works on the principle of photoelectric effect $E=hy$, When light radiation falls on the p-n junction diode, electron – hole pairs are generated by the absorption of the radiation. The electrons are drifted to and collected at the n-type end and the holes are drifted to p-type end. When these two ends are electrically connected through a conductor, there is a flow of current between the two ends through the external circuit. Thus photoelectric current is produced.

Applications:

PV can meet the need for electricity for parking meters, temporary traffic signs, emergency phones, radio transmitters, water irrigation pumps, stream-flow gauges, remote guard posts, lighting for roadways, and more.

Advantages of PVcells:

- Fuel source is vast and infinite.
- No emissions, no combustion or radioactive residues for disposal.
- Does not contribute to global warming or pollution.
- Low operating cost and high reliability.
- No moving parts and so no wear and tear.
- No recharging is required.
- They do not corrode.

Disadvantages of PV cells:

- Sunlight is relatively low density energy.
- High installation cost.
- Energy can be produced only during daytime.

E -waste Management

Introduction:

Electrical and electronic equipment contain different hazardous materials which are harmful to human health and the environment if not disposed off carefully. While some naturally occurring substances are harmless in nature, their use in the manufacture of electronic equipment often results in compounds which are hazardous (Chromium becomes Chromium VI). The infrastructure to deal with abundant e-waste in the developing countries is insufficient in terms of technology, techniques is the root cause of concern as more than 90% e-waste is treated with rudimentary and primitive techniques adopted by informal agencies. The presence of these pollutants in the atmosphere creates various kinds of diseases. To prevent the human being and environment from contamination of these pollutants, it is desirable to manage e-waste scientifically and to follow reuse and recycle methodologies.

Sources of e-Waste

A generic word E-waste is globally used for waste created this waste stream. It has been defined as **“E-waste is any electrical or electronic equipment that’s been discarded”**.

Major Sources of E-Waste is comprised of

- a) Large Household appliances such as Refrigerator, Freezers, Microwaves, Electric heating appliances, Electric radiators and conditioning equipment. CD players, TVs, radios, drillers. Air conditioner, grinder, iron, heater, military and laboratory electronic equipment’s, etc.
- b) Informal communications and technology equipment such as Computers, Laptops, Computer accessories, Printers, Copying equipment. Fax machines, photocopiers, printers, toners, ink cartridges, batteries, re-chargeable batteries, digital calculators and clocks, CRT monitors, electric solders, computer mother boards, key board. Televisions, Mobiles, Ipods etc
- c) Consumer electronics include Toasters, Coffee machines, Clocks, Watches, Hair dryer, Shavers.

Constituents of e-waste

COMPONENTS	CONSTITUENTS
Printed circuit boards	Lead & cadmium
Cathode ray tubes (CRTs)	Lead oxide & Cadmium
Switches & flat screen monitors	Mercury
Computer batteries	Cadmium
Capacitors and transformers	Poly Chlorinated Bi-phenyls (PCB)
Cable insulation/coating	Poly Vinyl Chloride (PVC)

Need for e-waste management concerning global perspective

The new challenge of e-waste management system is to shift the paradigm for a toxic pollution source to available resource in the context of sustainable development. Waste hierarchy concept focuses on waste prevention and 3R policy (reduce, reuse and recycle) and give less attention to landfill.

Challenges for E-waste management:

1. Lack of awareness and financial incentives
2. Less information on E-waste generation rates
3. Mismanagement in end of life products
4. Environmentally unsustainable informal sector practices
5. Inadequate regulatory design and enforcement

Consequently, they bear the greatest burden of adverse health hazards and ecosystem degradation, prolonging their achievement of sustainable development goals.

The Negative effect on human health

E-Waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony and phthalates. Long-term exposure to these substances damages the nervous systems, kidneys, bones, reproductive and endocrine systems. Some of them are carcinogenic and neurotoxic.

The Negative Effects on Air

Contamination in the air occurs when e-waste is informally disposed by dismantling, shredding or melting the materials, releasing dust particles or toxins, such as dioxins, into the environment that cause air pollution and damage respiratory health.

The Negative Effects on Soil

When improper disposal of e-waste in regular landfills, the heavy metals and flame retardants can seep directly from the e-waste into the soil, causing contamination of groundwater or contamination of crops that may be planted nearby. When the soil is contaminated by heavy metals, the crops become vulnerable to absorbing these toxins, which can cause many illnesses and doesn't allow the farmland to be as productive as possible.

The Negative effect on water bodies

The heavy metals from e-waste, such as mercury, lithium, lead and barium, then leak through the earth and reach groundwater. When these heavy metals reach groundwater, they eventually make their way into ponds, streams, rivers and lakes. The pH of the water bodies changes due to the presence of these heavy metals and affect the pond-eco system.

Health hazards of e-waste

Solder: Solder contains lead that damages the nervous system, blood system, and kidney and also affect the development of brain in children.

Relays, Switches and Printed Circuit Boards:

Mercury present in these elements leads to brain damage, disorders in the respiratory system and skin diseases.

Corrosion Protectors:

Asthmatic bronchitis and DNA damage are caused due to the Hexavalent Chromium present.

Cabling and Computer Housing:

When burn these produce dioxin, which causes problems of reproduction, destruction of the immune system, and regulatory hormones are damaged too.

Brominated Flame Retardants:

BFRs increases contamination of the environment, wildlife, and people. These do not decompose easily in the environment, and long term exposure can cause impaired memory function and learning. Pregnant women exposed to brominated flame retardants have been shown to give birth to babies with behavioral problems as it interferes with estrogen and thyroid functioning.

Arsenic: Arsenic is a poisonous metallic element which is present in dust and soluble substances. Chronic exposure to arsenic can lead to various diseases of skin and decrease nerve conduction velocity. Chronic exposure to arsenic can also cause lung cancer and can often be fatal.

Cadmium: Cadmium can easily be accumulated in human body. Acute exposure to cadmium fumes causes flu-like symptoms of weakness, fever, headache, chills, sweating and muscular pain. Long exposure to Cadmium causes lung cancer and kidney damage. It also causes pulmonary emphysema and one disease (osteomalacia and osteoporosis).

Extraction of gold from e-waste

E-waste has been a major segment of the waste produced in the past decades. Second-hand computers, mobile phones, and televisions made up an estimated 9.8 million tons of e-waste in 2015. Scientific reports have shown that developing countries will produce twice the amount of e-waste of developed countries by 2030. Recovering precious metals from e-waste through hydrometallurgical processes is more attractive economically than other methods.

Process:

Step 1: CPUs are ground well, (grinding of the CPUs): First, any dust or other particles were removed from the CPUs. The size of the grind pieces was 1 mm so that good contact between the sample and acid.

Step 2: Leaching with Nitric acid

Powdered sample was digested with Conc.HNO₃ for 1 Hr and loss of gold can be prevented by carrying out digestion at room temperature and amount of acid consumed is directly proportional to CPU powder.

Step 3 (leaching in aqua regia): The aqua regia solution was obtained using three volumes of HCl plus one volume of HNO₃ (under the hood). Typically, the gold of composite CPU-containing boards is easily dissolved in 4-to-1 aqua regia. The reaction releases bubbles and is followed by sublimation of NO₂ brown gas. The solution was decanted, and the pieces were subsequently washed with 10 mL of concentrated HCl so that all of the gold content was fed into the solution.

Step 4 (removing the excess nitric acid): Sulfuric acid was added to the solution to accelerate the removal of nitric acid and sedimentation of the lead as lead sulfate (if present). The time required for the complete removal of nitric acid from this solution was 45 minutes. At this stage, the solution's color was golden yellow and the solution's pH was around 0.5. If any deposit was observed (possibly related to silver chloride), it was separated by a filter.

Step 5 (precipitation of gold): A certain amount of iron sulfate (per one gram of gold: 4.2 g of iron sulfate) was dissolved in warm water and gradually added to the gold-containing solution. For better dissolution of iron sulfate, some drops of HCl can be used.

Step 6 (washing and purifying gold deposits): The deposit was coated with HCl and then boiled (to dissolve the excess copper sulfate). Following boiling, the acid was removed and the deposit was re-washed in HCl to ensure the cleanness of the gold powder. Eventually, the deposit was filtered and washed with large amounts of warm water. At this stage, the deposit was placed in an oven at a temperature of 100°C to dry. Gold powder obtained was weighed.

