Module -V

ENERGY SOURCES & STORAGE DEVICES

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5.2 Storage devices

5.2.1 Batteries

Batteries are energy storage devices. The energy stored in the batteries can be utilized later. It is portable energy storage device.

Definitions

- **A cell** is an electrochemical device that converts chemical energy to electrical energy. It contains one anode and cathode with an electrolyte.

- **Battery** is an arrangement of several electrochemical cells connected in series to produce direct electric current. A battery contains several anodes and cathodes.

5.2.2 Types of batteries

1. Primary battery (or) Primary Cell (or) Non- reversible cell
2. Secondary battery (or) Secondary Cell (or) Reversible battery
3. Flow Battery (or) fuel cell

1. Primary Battery

In a primary battery,the electrodes reactions cannot be reversed by passing external electrical energy .They are not chargeable. (eg) Dry cell, alkaline battery, mercury cell.

2. Secondary Battery (Accumulator)

In a secondary battery, the electrode reactions can be reversed by passing external electrical energy .They are chargeable and can be used again and again. They are called accumulators or storage cells.

(eg) Lead –Acid storage, Nickel- Cadmium Cell, Lithium ion cell.

3. Flow battery or Fuel Cell

They are cells in which reactants, products and electrolyte pass through the cell continuously.

Here chemical energy is converted to electrical energy without combustion.

(eg) H_2- O_2 fuel cell

Fuel Battery

A large number of fuel cells are connected in series to from a Fuel battery.

5.2.3 Dry cell or Leclanche's cell

A cell without fluid component is called as dry cell.

Example: Daniel Cell, Alkaline Battery.

Description

Anode - Zinc (Zn) cylinder

` Cathode – Graphite rod

Electrolyte – paste of NH_4Cl, $ZnCl_2$ and MnO_2 with starch and water.

Out put voltage – 1.5 V

Cell representation

Zn / $ZnCl_2$ // Pasty electrolyte / MnO_2 / Mn_2O_3

Cell Reaction

Anode: $Zn_{(S)} + 2Cl^- \longrightarrow ZnCl_2 + 2e^-$

Cathode: $2NH_4^+{}_{(aq)} + 2MnO_{2(s)} + 2e^- \longrightarrow Mn_2O_3 + 2NH_3 + H_2O$

Cell reaction: $Zn_{(s)} + 2NH_4Cl_{(aq)} + 2MnO_{2(s)} \longrightarrow ZnCl_2 + Mn_2O_3 + 2NH_3 + H_2O + Emf$

NH_3 released disrupts the current flow, this is prevented by reaction with $ZnCl_2$.

$$2NH_3 + ZnCl_2 \longrightarrow [Zn(NH_3)_2]Cl_{2(s)}$$

Uses

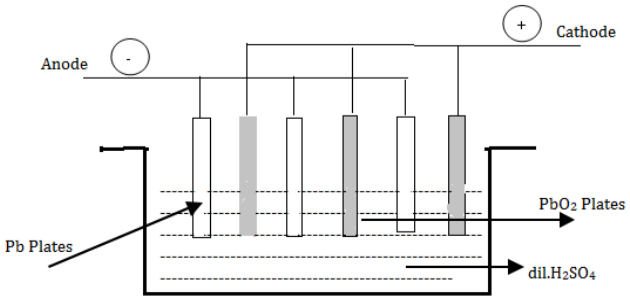
Dry cells are used in flash-lights, transistor radios, calculators, etc

Disadvantages

- When current is drawn rapidly, drop in voltage occurs.
- Since the electrolyte is acidic, Zn dissolves slowly even if it is not in use.

5.2.4 Lead-Acid Battery(or) Lead Storage Battery

- It is a 2^o battery.
- It can act as voltaic cell and electrolytic cell.
- During discharging – it acts as voltaic cell
- During recharging – electrolytic cell.



Description

Anode – Pb plates

Cathode – PbO_2 plates

Electrolyte – dil.H_2SO_4

- The electrodes are arranged in alternate pattern.
- The electrodes are separated by insulators like rubber, wood etc.
- Single cell produces 2V.

Working

Cell representation

Pb / $PbSO_4$ // H_2SO_4(aq) / PbO_2 / Pb

1) Discharging

At anode: $Pb + SO_4^{2-} \longrightarrow PbSO_4 + 2e^-$

At cathode: $PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \longrightarrow PbSO_4 + 2H_2O$

Overall reaction: $Pb + PbO_2 + 2H_2SO_4 \xrightarrow{\text{Discharging}} 2PbSO_4 + 2H_2O + Emf$

The formation of $PbSO_4$ shows that H_2SO_4 is being used up.

2) Recharging

- For recharging, electric current is passed in the opposite direction.
- During recharging Pb deposits on anode and PbO_2 on cathode and concentration of H_2SO_4 increases.

$$2PbSO_4 + 2H_2O + \text{external current} \xrightarrow{\text{Recharging}} Pb + PbO_2 + 2H_2SO_4$$

Both discharging and recharging reactions can be shown as,

$$2PbSO_4 + 2H_2O + \text{Energy} \underset{\text{discharging}}{\overset{\text{Recharging}}{\rightleftharpoons}} Pb + PbO_2 + 2H_2SO_4$$

Uses

1) It is used in cars , buses ,trucks etc,
2) It is also used in telephone exchanges , hospitals, power stations.

5.2.5 Lithium ion battery

- It is solid state battery because the electrolyte is in solid state.
- It is a rechargeable cell with high energy density.
- It can be recharged.
- The electrolyte is in solid state.
- Produces a voltage of 3V.

Construction

Anode : Lithium

Cathode : TiS_2

Electrolyte - Polymer packed between two electrodes

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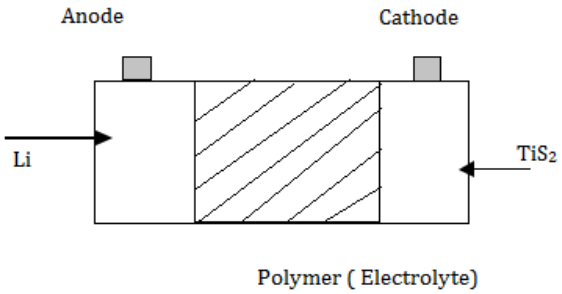


Working

a) Discharging

At anode: $Li_{(s)} \longrightarrow Li^{+} + e^{-}$

At cathode: $Tis_2 + e^{-} \longrightarrow Tis_2^{-}$

Discharging

Overall reaction: $Li_{(s)} + TiS_{2(s)} \longrightarrow Li^{+} + TiS_2^{-} + Energy$

b) Recharging

Recharged by passing current in opposite direction.

Recharging

$Li^{+} + TiS_2^{-} + Energy \longrightarrow Li_{(s)} + TiS_{2(s)}$

Both discharging and recharging can be shown as,

discharging

$Li^{+} + TiS_2^{-} + Energy \rightleftharpoons Li_{(s)} + TiS_{2(s)}$

recharging

Advantages (or) Reasons for Lithium battery called as 'Cell of future '

a) High voltage of 3V is got.

b) No leakage, as all constituents are solids.

c) Weight of battery is low (Li is light weight metal).

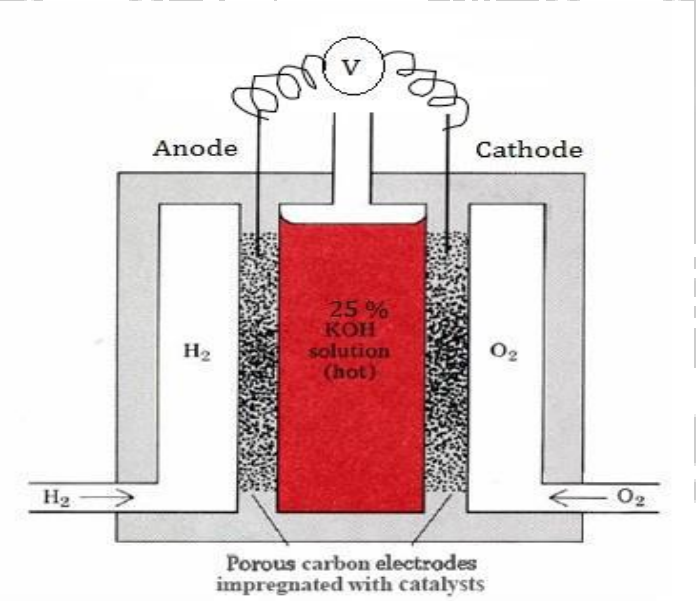
d) Battery can be made in variety of shapes and sizes.

5.2.6 $H_2 – O_2$ Fuel Cell

- It is the simplest fuel cell.
- It is a voltaic cell.
- The emf of the cell is 0.8 – 1.0 V

Description

- Fuel – H_2 (anode compartment)
- Oxidiser – O_2 (cathode compartment) } flows through the cell
- Electrolyte –liq. NaOH(KOH) (25%)
- Anode & Cathode –Porous electrode made of compressed carbon (Graphite rod) with little amount of catalyst. (Pt, Pd, Ag).
- Electrodes are connected through a voltmeter.



Working

At anode

- H_2 gas is bubbled through the anode compartment.
- H_2 is oxidized and electrons are liberated, which then combines with OH^- ions to form water.

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

At cathode

- O_2 gas is bubbled through the cathode compartment.
- The electrons produced at the anode react with O_2 and water to produce OH^- ions.

$$O_2 + 2H_2O + 2e^- \longrightarrow 2\ OH^-$$

Overall reaction

$$H2 + \tfrac{1}{2}O2 \longrightarrow 2H2O$$

Applications

- Used as energy source in space vehicles, sub marines etc.
- The product obtained water is a source of freshwater for the astronauts.

Advantages

- Efficiency is 70% greater than other energy sources.
- The product formed is harmless (water).
- There is no noise and thermal-pollution.

5.2.7 SUPER CAPACITORS

Capacitor

A device that stores charge in an electric circuit is a capacitor.

Super capacitor

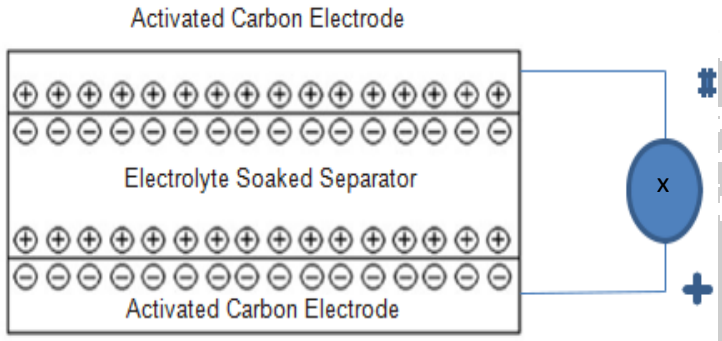
A device that stores electrical energy electrostatically by polarizing an electrolytic solution. They are otherwise called as double-layer capacitors or ultra-capacitors.

Principle

Electrical energy is stored electrostatically by polarizing an electrolytic solution.

Construction

It consists of two porous electrodes, an electrolyte, a separator and a current collector.



Working

- When voltage is applied to the +ve plate, it attracts the –ve ions from the electrolyte.
- When voltage is applied to the –ve plate, it attracts the +ve ions from the electrolyte.
- This results in formation of a double layer.
- The ions are stored near the surface of the carbon.
- The separator prevents the movement of ions across the electrodes.
- Huge amount of energy is stored due to the large surface area provided by the porous carbon electrodes.

Advantages

- It works for long time without wearing and ageing.
- It takes seconds to charge completely.
- It is of low cost.
- Faster energy release.

Disadvantages

- It has low energy density.
- Not all energy can be utilized during discharge.
- Has self-discharge higher than the batteries.

Applications

- Used in power conditioning and UPS.
- Used in industrial lasers and medical equipments.
- Used in wireless communication.
- Used in VCR's, CD players, electronic toys, security systems, scanners, smoke detectors and coffee makers