Energy Storage System.

Introduction :-

A battery is a compact device consisting of two or more galvanic cells connected in series or parallel or both.

It stores chemical energy in the form of active materials and on demand converts it into electrical energy through redox reactions. Thus, a battery acts as portable source of electrical energy.

* (6-M) Classification of battery :-

Batteries are classified as,

i) Primary batteries.
ii) Secondary batteries. and
iii) Reserve batteries.

i) Primary batteries :-

In Primary batteries, the cells reactions are not reversible. They are not rechargeable and once discharged have no further electrical use.
Ex:- $Zn-MnO_2$ battery, $Li-MnO_2$ battery.

ii) Secondary batteries :-

In secondary batteries, the cell reactions are reversible. They are also called storage batteries. The discharged cell can be recharged by passing current through it in the direction opposite to that of discharge current.

Shelf life - length of time a battery can remain in storage without losing its capacity

Ex:- Lead storage battery, nickel-cadmium battery.

iii) Reserve batteries :-

One of the components in the reserve batteries is stored separately and is incorporated into the battery when required. Usually, the electrolyte is stored separately. ~~from electrodes, to avoid~~ the activation is done by adding the electrolyte to the cell components when required.

These are primarily used to deliver high power for relatively short period of time in applications such as radiosonodes, missiles, mid-ocean disasters, crisis in space.

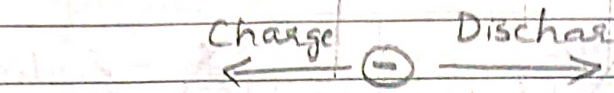
Eg:- Mg batteries activated with water (Mg - AgCl and Mg-CuCl), Zn - Ag_2O batteries

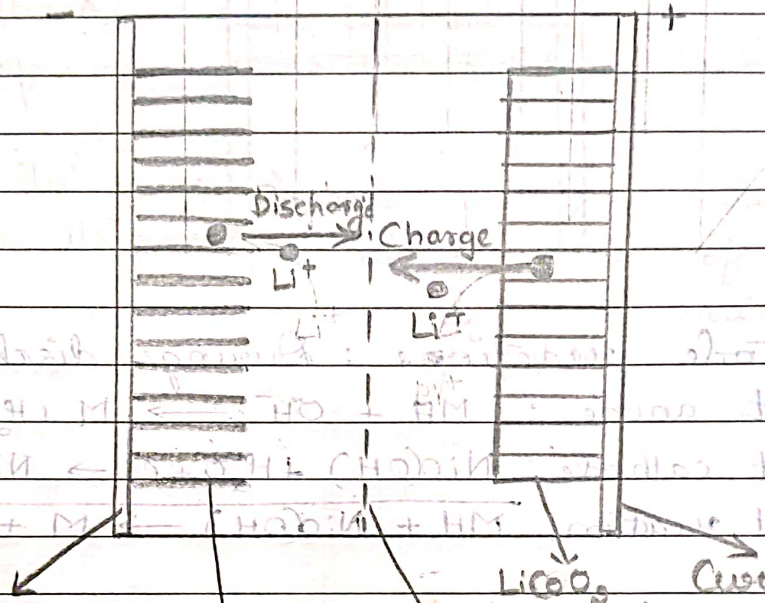
- Advantages of reserve batteries :-
  - Long shelf life.
  - High performance reliability &
  - variety of design options.

Shelf life - length of time a battery can remain

iii (6M) *

Lithium - ion battery :-





(7M) *

Construction :-

Li-ion cell has 4 layer structure.

- Cathode (positive electrode) is made with lithium cobalt oxide, and it has a current collector made of thin aluminium foil.
- Anode (negative electrode) is made with graphite and it has a current collector of thin copper foil.
- A separator is Microporous polyethylene or polypropylene.
- Electrolyte is made with lithium salt such as $LiPF_6$ (lithium hexafluorophosphate) in organic solvents like ethylene carbonate, dimethyl carbonate and diethyl carbonate.

Representation :-

x-Li-Graphite | $LiPF_6$ in organic solvent | $Li_{1-x}CoO_2$.

Lithium ion batteries produce 3.6 volts.

Working :-

Both the electrodes allow Lithium ions to move in and out of their interiors.

During charging, lithium ion in cathode material is ionised and moves from cathode to anode and gets inserted into the anode. This will take place till all the Li in cobalt oxide are over and accomodated in graphite and no more current can flow.

During discharge, Li ions are dissociated from the graphite anode and migrate across the electrolyte and are inserted into the cathode layers.

The process is completely reversible.

During charging, cell reactions are as follows,

+ electrode Cathode $LiCoO_2 \longrightarrow Li_{1-x}CoO_2 + xLi^+ + xe^-$

Electrons flow from cathode to anode at charging.

- electrode Anode $xLi^+ + xe^- + Graphite \longrightarrow xLi\text{-}Graphite$.

During discharge, e flow from anode to cathode & current flow from cathode to anode.

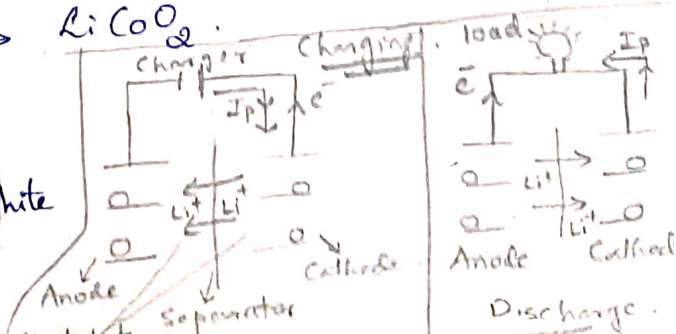
During discharging, the above reactions are reversed.

Anode $xLi\text{-}Graphite \longrightarrow xLi^+ + xe^- + Graphite$.

Cathode $xLi^+ + xe^- + Li_{1-x}CoO_2 \longrightarrow LiCoO_2$.

Net reaction :-

$$LiCoO_2 + Graphite \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Li_{1-x}CoO_2 + xLi\text{-}Graphite$$



Advantages :-

High energy density.
High voltage.
Fast charge & discharge rate
Less weight
Produce 3.6 V.
Improved safety.

Applications :-

Li-ion batteries are used in cameras, calculators, cardiac pacemakers, telecommunication equipment, portable radios, and TVs, laptop computers, mobile phone and aerospace application.

Limitations :

Expensive.
Not available in standard cell types.
Volume expansion of anode (as anode is absorbing lithium).
Heating up of battery during charging & discharging may happen
Organic electrolyte i.e, Li-Salt (it may catch fire with application of heat)

• amount of energy that can be stored in a given mass of substance.