19/5.

Unit → 4

Electrical Installations

Components of LT Switchgear.

- The apparatus used for switching, controlling and protecting the electrical circuits and equipment is known as switchgear.
- It essentially consists of switching and protecting devices such as switches, fuses, circuit breakers, relays, current transformers

FUSE :-

- It is a short piece of wire which melts when excessive current flows through sufficient time.
- Whenever the current flowing through fuse element increases beyond its rated capacity then short circuit or overload occurs.
- This raises the temperature and the fuse element melts, disconnecting the circuit.

Switch Fuse Unit (SFU) :-

- It has one switch unit and one fuse unit.
- Whenever we operate the breaker, the contacts will get close through switch and then the supply will passes through fuse unit to output.
- Whereas in fuse switch unit there is no separate switch and fuse unit. There is only fuse unit which act as a switch.

* MCB [Miniature Circuit Breaker].

- It is an electromechanical device which guards an electrical circuit which automatically switches off electrical circuit during abnormal condition of network means in over load condition as well as faulty condition. - It is more sensitive to over-current than fuse.
- Normal current rating is from 0.5 - 63 A.

→ **Construction :-**

(a) External casing - It hold internal components firm and protects them from dust. It is made of insulating materials such as plastic or ceramics.

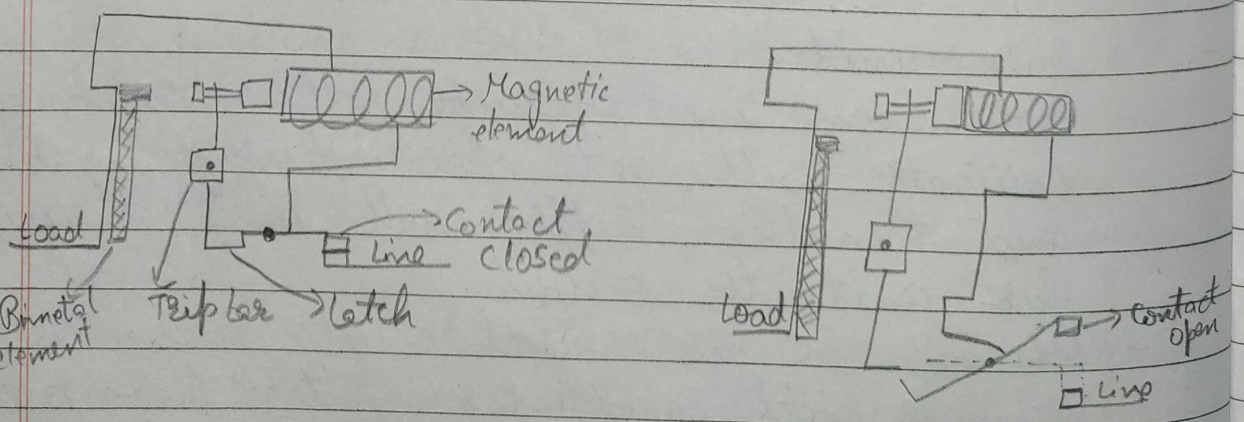
(b). Contacts - A pair of contacts can be found inside an MCB. One of them is fixed and other is movable.

(c). Knob - MCB can be turned on/off using this knob.

(d) Mechanical latch - It hold the contacts under spring tension at on position.

(e). Bimetallic strip - It offers delayed overload protection by sensing overflow of current.

(f). Arc chutes :- It is used for splitting of arcs.



→ Principle = Electromagnetic effect; Thermal effect.

→ Operation :

(a) Switching - MCB can be switched on/off manually. This function is highly useful, especially during maintenance.

(b) Overcurrent Protection - When piece of equipment is overloaded it draws more current from source. This current flows through bimetallic strip and heats it up. It will knock down the latch, opening the contact and isolation from supply.

(c) Short circuit Protection - A sudden rise in current produces MMF powerful enough to project plunder towards latch and releases it, thereby opening contacts.

→ Need = To protect appliance against sustain overloading and short-circuit.

Short circuit = 10-100 X Normal current } more dangerous.

Overload = 2-5 X Normal current.

→ Types.

Type	Tripping current	Operating Time	Use
B	3-5 times FLC (full load current)	0.04 to 13 sec	Resistive, Domestic Application
C	5-10 times of FLC	0.04 to 5 sec	Commercial & Industrial use
D	10-20 times	0.04 to 3 sec	High-starting current.
K	8-12 times	less than 0.1 sec	Battery charge, X-Ray Machines
Z	2-3 times	less than 0.1 sec	Semi-conductor

→ Advantages :-

- Handling of MCB is safer.
- Restoration of power supply quickly.

- During abnormal conditions, it automatically switches off electrical circuit.

→ Disadvantages :-
- Slow tripping
- Vulnerability to heat.
- More expensive than fused switches.
- Can not protect against earth faults.

[MCCB] Molded Case Circuit Breaker
- It is commonly used when load currents exceed the capabilities of MCB.
- The shunt trip is used to disconnect main power supply to circuit.

[ELCB] Earth Leakage Circuit Breaker / RCCB
new version
- They are voltage detecting device. [Residual current circuit Breaker]
- It is one kind of safety device used for installing an electrical device with high earth impedance to avoid shock.

Types :-

voltage operated	Current operated
• Trips when voltage drops in circuit.	Trips when current drops in circuit.
• voltage drop must be around 50 volts.	Current must be around 30m Ampere.

→ Contactors => Special type of relay capable of switching higher power loads such as motor, electric heaters.

Wire.

It is a flexible strand of metal that transport electricity.

(a). Aluminium wire
- lesser conductivity
- less Expensive, light weight
- R = 60% of copper
  R ↑ (Resistivity)

(b) Copper wire
- Higher conductivity
- More Expensive
- R (↓).
- Less corrosive
  Heavy weight

$$\downarrow R = \frac{\rho l}{a \uparrow}$$

Aluminium conductor requires 56% larger cross-sectional area than copper for same current carrying capability. But still it's cost is less than that of copper. So, we prefer Aluminium conductor.

=> Types of Wire:-

i). Solid wire = Also called solid-core or single-strand wire, consists of one-piece of metal wire.
It is used for carrying high currents.

ii). Fuse wire = It is a piece of wire of a material with very low melting point.
They are mainly made up of tin, lead / zinc.

(iii) Magnet wire [Enameled wire] = It is used for interchanging electrical energy with magnetic energy. It is a copper or Al wire coated with thin layer of insulation.

(iv). Stranded wire = It refers to thin bundled up wires that are compressed and covered

up in insulating material.
Flexible ; Malleable ; will not split.
More long lasting, ~~flex~~ less Eddy current loss.

(v). Litz wire = It is a particular type of multistrand wire used in electronics to carry AC at radio frequencies.

→ On the basis of supply.

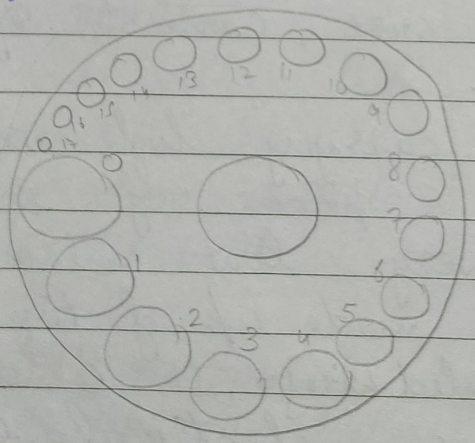
(i) Live wire (R, Y, B). = It is the wire that is active for carrying current in circuit.

(ii) Neutral wire [Black wire] = It is a type of wire which carries current back to source of power.

(iii) Ground / Earth wire [green] = It is used to give excess electrical charges a safe place to go.

→ On the basis of diameter =

Gauge wire ; [AWG] = American standard.



↓

It is the measurement of wire diameter.

10 - gauge
8 - gauge
6 - gauge
; etc.

→ On the basis of overhead lines.

(i) AAC (All Al conductor).
- Made up with pure aluminium (99.7%) purity.
- 61% conductivity ; used in urban areas.

(ii) AAAC [All Aluminium Alloy conductor].
- Alloy of [Al + Mg + Si]
- Better conductivity, mechanical strength
- 52.5% conductivity.
- used in coastal area.

(iii) ACSR [Aluminium Conductor Steel Reinforced].
- It provides thin layer of zinc coated on steel strand for corrosion protection.
- Sag point is less.

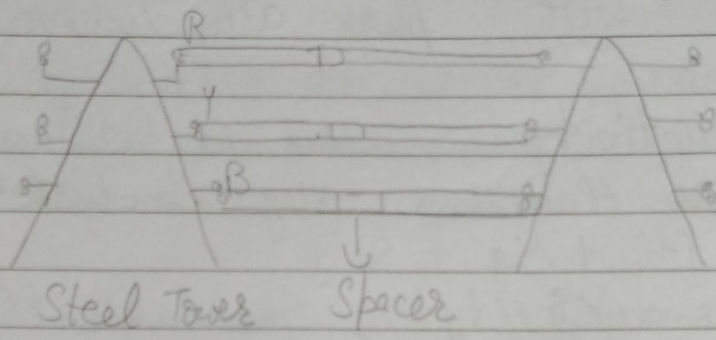
(iv) ACAR [Aluminium conductor Alloy Reinforced].
- Formed by pure Al wrapped in alloy strands.
- Better conductivity and mechanical strength

→ Alloy :- It means combine 2 or more than 2 metals and create a new metal, called alloy.

⇒ Conductors :
(i) Stranded conductor = They are made of multiple small strands, which group together to make single conductor.

[upto 220 KV]

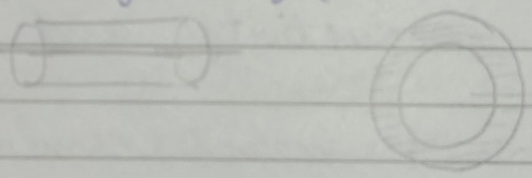
(ii). Bundle conductor = It is a conductor made up of two or more sub-conductors and is used as one-phase conductor.



- Used for transmission system above 220 KV voltage level.
- Low corona loss due to large cross section of area.

(iii) Solid conductor = Solid wire.

(iv) Hollow conductor = The conductor that allows flow of charges through centred channel.



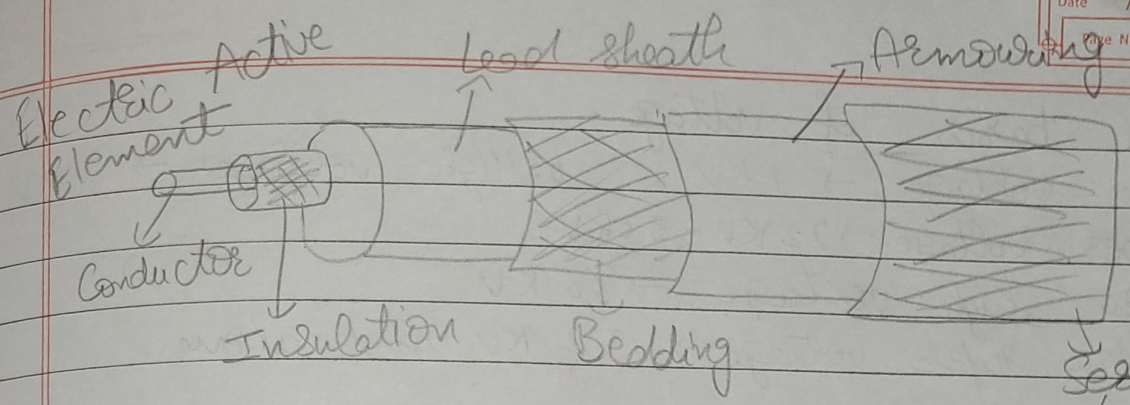
⇒ Cables :- group of wires inside rubber or plastic covering (PVC). Insulators.

* Properties => • High insulating Resistance
  • High dielectric strength
  • less passage of current should be there.
  • Non-hygroscopic [do not absorb moisture]
  • High melting point

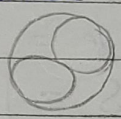
Types of Cables :-

1) On bases of core =>

(a) Single core Cable = Cable with single conductor.



(b). 2 core Cable.
- One as face and other as neutral.
- Used in telephone service and to connect computer device.



(c). 3.5 core Cable.
- It is treated as half - conductor.
- Three wire of full size for three phases.
- The fourth is half the size for neutral.

(d). 3 core cable.
- 3 wire of full size for three phases.

(e). 4 core cable.
- In case of unbalanced load some neutral current exists. Therefore in some cases 4 core cable is preffered.
- Used for lighting ; load distribution.

(f). Armored Cable.
An electrical conducting cable with a wrapping of metal
→ 1. Wire - Braid Armour
→ 2. Single - wire Armour

(g). Unarmoured Cable.
It is not protected against mechanical damage.
→ 1. Steel-Tape Armour
→ 2. Normal unarmoured

2) On basis of Voltage.

a. low voltage → 1 KV b. High voltage → 11 KV

c. Super voltage → 22 KV - 33 KV

d. Extra high voltage → 66 KV

e. Extra super voltage → 132 KV and above.

3) On Aspect of Insulation.

a. PVC cable = 250 volt - 440 volt 650 - 1000 volt.

- Uses only where temperature is not too high.
- Generally use = in domestic & Industrial area.

b. CTS or TRS = [Cable type sheathed]

- very heavy in weight.
- Use when high moisture is there.
- 250 - 440 volt.
- Use in telephone wire.

c. VIR Cable. [Vulcanised India Rubber]

- Used in house wiring.

d. lead Sheathed Cables.
Mechanical strength is high.

e. Flexible cable.
Cable with extra flexibility & durability.

f. PVC cable = used for wire insulation or cable jackets.

- Thermoplastic material is used.

g. XLPE cables = Cross linked polythylene cable.

h. Waterproof Cable = water - resistant cables.
Designed for wet applications.

i. Multi- Strand cable = It come with bunch of small wires to form one - thick conductor.

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Types of wiring.

1). Cleat wiring = • It is a temporary wiring system therefore not suitable for domestic premises.
- It comprise of ordinary PVC insulated wires braided on walls by means of wood / plastic.
- It is simple and cheap.

2). Casing and capping
- One of oldest wiring system.
- PVC insulating wires are placed in plastic casing and covered with a cap.

3). Batten wiring. =
When a single electrical wire & group of wires are laid over wooden batten.

4). Conduit wiring =
a. Surface Conduit wiring = when PVC conduits are installed on walls.
b. Concealed Conduit wiring = When conduit are hidden inside wall slots & brick walls.

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Cable - Selection.

1. Type of cable
2. Size of cable. → wire gauge.

- Wire - Size used in house wiring:
  1 SQ MM
  1.5, 2.5, 4, 6, 10 SQ MM
- Choose MCB Breaker current rating.
  For 1 Sq mm use 6 amp MCB ...
- Module.
  1 Switch plate = 1 Module
  3 Switch plate = 3 Module.

⇒ Earthing =>. When there is a fault in machine or any electrical system; with help of Earth, the surge current goes to ground.

- It provides the simple path to leakage current.

Types

Conventional Earthing

- Plate Earthing
- Road Earthing
- Pipe Earthing [chemical Earthing].
- Strip Earthing

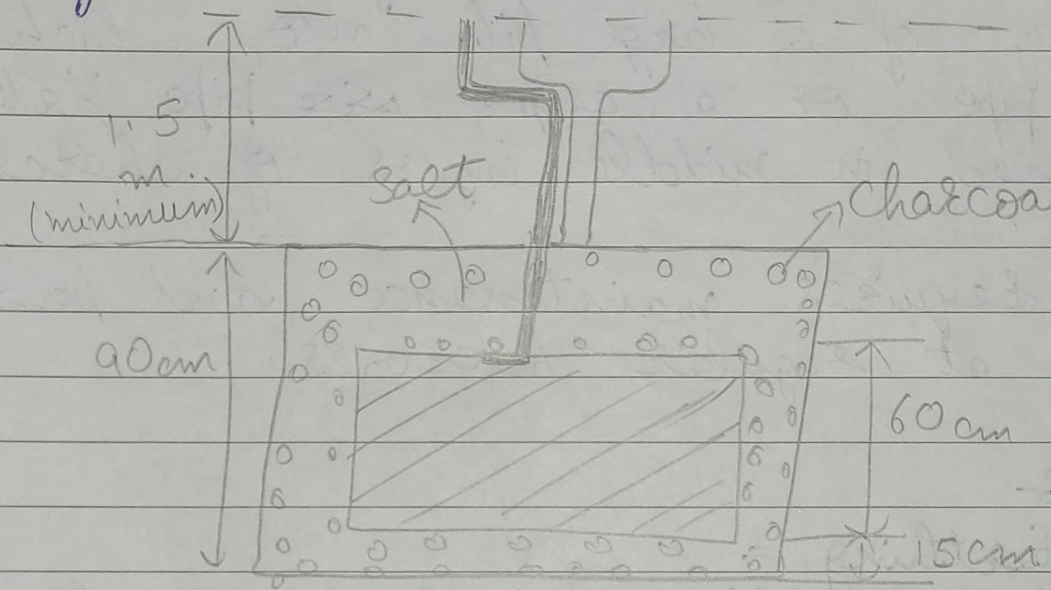
Maintanance Earthing

* The conventional Earthing calls for digging of a large pit into which a G.I pipe or a copper ~~wire~~ pipe plate is positioned in middle layers of charcoal or salt.
* It requires maintenance and pouring of water at regular intervals.

Types :-

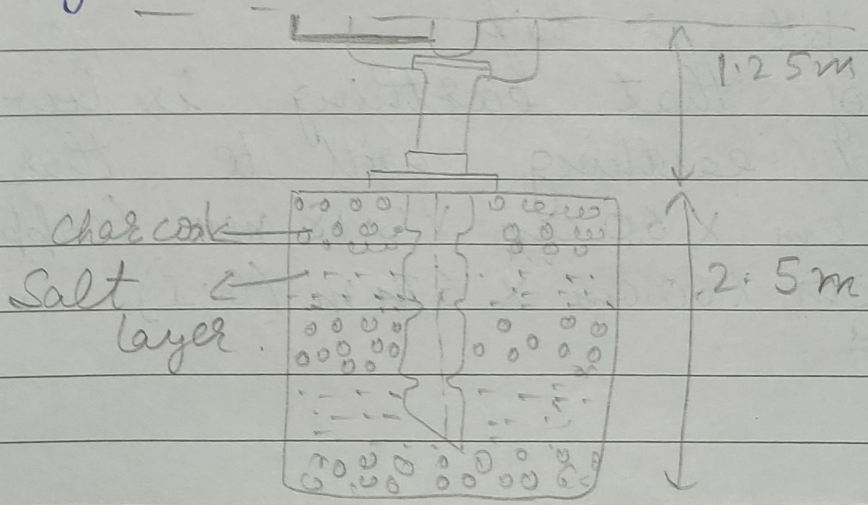
1) Plate Earthing =
- In this earthing plate either of copper or G I (Galvanized Iron) is buried into ground at depth of not less than 3m from ground level.
- It is used in places where large number of current flows.
- Dig 5-12 feet Pit.
- Depth of pit is high
- means R of that earthing is low.
- means good earthing will be there.
- Size → 60 cm X 60 cm X 3.18 mm (copper)
  → 60 cm X 60 cm X 6 mm (G.I)

- Diagram =>



2). Pipe Earthing =

- Also known as heavy earthing.
- Pipe could be made by Cu or Cu I.
- Depth -> 3.75 m
- 2.5 m in length.
- Diagram.



3). Rod Earthing =

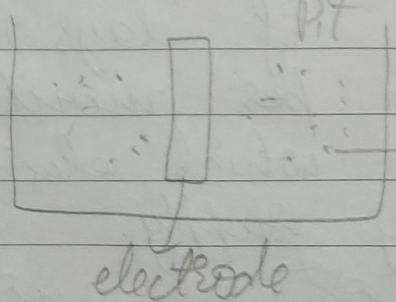
- Temporary Earthing / used for Street light Earthing.
- It is done by digging very deep in sandy area as moisture content is high.
- length of rod = 1 - 1.5 m
  dia = 12 mm - 20 mm

4). Strip Earthing =

- Used in Rocky land.
- It is widely used in long-distance transmission lines.

5). Chemical Earthing =

- Name of chemical = Bentonite
  [High capacity to hold the moisture].
- Dig a pit * place a electrode into it.
- Put chemical instead of coal & salt.



- Chemical Powder Compound → Black [heavy carbon] = Normal places
  → Brown [Bentonite] = where dryness ratio is high.
  like = sandy areas.

⇒ Elementary Calculations for Energy Consumption

Electric bill measure in = units.
1 Unit = 1 Kwh / 1000 wh

Calculation [steps].

① For each appliance; multiply power (in W) with average time (in hours); per day.
② Add the results to get total consumption (in W-h) per day. [because it is too small for practical purposes]
③ Since electricity is measured in KW-h, we divide consumption by 1000 to get total consumption in KW-h (per day).
④ Multiply it by number of days in month, to get total consumption per month.
⑤ Find tarrif [i.e rate at which electricity is supplied] of electricity supply.
⑥ We will get estimated cost per month.

Appliances	Power	Quantity	Time period	watt-hour
Fan	10W	2	6 hours/day	$10 \times 2 \times 6 = 120$
Fridge	50W	2	5 hr/day	$50 \times 2 \times 5 = 500$
AC	100W	2	1 hr/day	$100 \times 2 \times 1 = 200$
				820

820 W-h $\Rightarrow \frac{820}{1000} \Rightarrow 0.82$ Kwh

Days → Month

Month of march = 31 days

$= 0.82 \times 31$

$= 25.4$ Kwh

Tarrif = Rate [7 Rs /unit].

$= 25.4 \times 7$

$= 177.8$ units #.

→ Cells and Batteries

Principle = Convert Chemical Energy into Electrical Energy → cell.

Practically, voltage of single cell is not sufficient to use in practical applications. Hence various cells are connected in series or parallel to obtain required voltage level. The combination of various cells, to obtain desired voltage level is called a battery.

Types of Cells:-

1) Primary Cells
2) Secondary Cells.

1) **Primary Cells** => The chemical action in such cells is not reversible and hence entire cell is required to be replaced by a new one if cell is down. Primary cells can produce limited amount of energy. These are made up of electrochemical cells.

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youvA

Examples; Zinc - Carbon Dry cell, Zinc chloride cell, Mercury cell, Lithium Cell etc.

* Applications ⇒
- Wrist watches
- Remote Controls
- Children Toys
- Flashlights / Torch lights
- Wall clocks

2). Secondary Cells ⇒ The chemical action in such cells is reversible. Thus if cell is down, it can be charged to regain original state; by using charging methods. These are also called storage cells; rechargeable cells.

Examples; Lead - acid cells, Nickle cadmium alkaline cell; etc.

* Applications ⇒
- Mobile Phones
- Gadgets
- Electric vehicles
- Power Portable Electronic Devices.

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Secondary Cells =>

1). Nickle - Cadmium [Ni - Cd].

- Anode [-ve electrode] => Cadmium.
- Cathode [+ve electrode] => Nickle oxide hydroxide.
- Electrolyte [KOH sol^{n}].
- These are good at maintaining voltage and holding charge when not in use.
- These offer good life cycle and good performance at low temperature.
- Nominal cell voltage is 1.2 V.

Applications =>

- Small packs are used in portable devices, electronics and toys.
- Bigger ones find in aircraft starting batteries, Electric vehicles and standby power supply.

2). Nickel - Metal Hydride.

- Anode → Hydrogen absorbing metal alloys.
- Cathode → Nickel Hydroxide
- Electrolyte → [KOH sol^{n}].
- Nominal cell voltage = 2 V

Application →

Used in high drain devices because of their high capacity and energy density.

3) Lithium - Ion

- Anode → Graphite / Porus carbon.
- Cathode → Li - Metal Oxide
- Electrolyte → Aq. solution dissolved with Li salt.
- One of most popular type of rechargable batteries.
- In this Li ions from negative electrode migrate to positive electrode during discharge and migrate back to negative electrode when battery is being discharged.
- ~~Nomina~~ Nominal cell voltage is 3.6 - 3.85 V.

Application →

- Mobile Phones
- Smart Devices
- Aerospace
- Military Applications due to light weight in nature

4). Lead - Acid Battery

- Anode - Lead Metal
- Cathode - Lead Dioxide
- Electrolyte - H_2SO_4.
- They are low - cost reliable power work horse used in heavy duty applications.
- They are very large because of their weight.
- They have very low energy to volume and energy to ~~load~~ weight ratio but has relatively large power to weight ratio.
- Low in cost and attractive for use in several high current applications.
- Nominal cell voltage is 2V.

Applications :-

- Solar - Panel Energy Storage
- Vehicle Ignition
- Back-up power
- Load - Levelling in power generation distribution.
- Powering Automobile Starter Motors.

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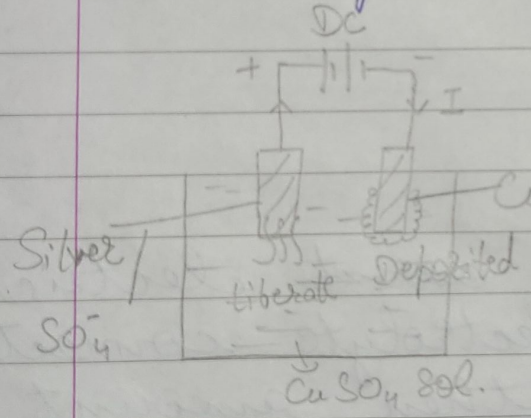
Faraday's laws of Electrolysis =>

When a substance dissociate into ions called Electrolysis.

→ I^st law

Mass of substance liberated or deposited at electrodes is directly proportional to amount of electricity passed through electrolyte during electrolysis.



- Apply High I = High Deposition & liberation.
- All process Depends upon Applied Electricity.

- Amount of mass deposited ∝ Electric (I) or charges pass.

- $M \propto Q$

  $M \propto It \quad \therefore \left[I = \frac{Q}{t}\right]$

$M = z\,It$

z ⇒ Electro - chemical equivalent.

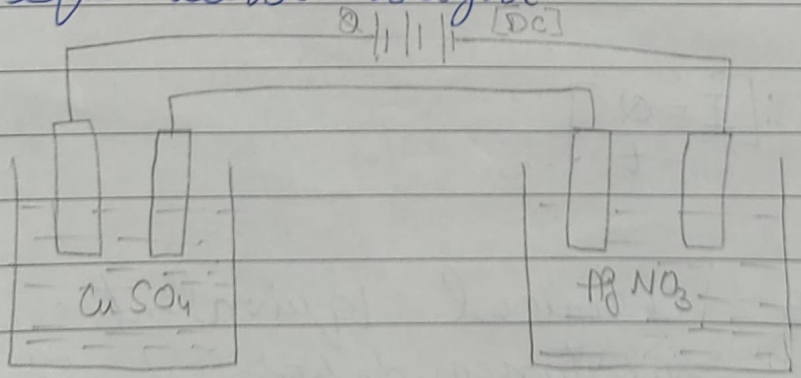
M = Mass of substance deposited or liberated

t = time for which Electricity is passed.

- Electrochemical Equivalent = When 1A, current pass through electrolyte for 1 second.
- Which material (electrolyte) will deposit on electrode depends only on the properties of electrolyte.
- Electrochemical Equivalent is usually express in (i) milligram / coulomb.
  (ii). milligram / volt
  (iii). milligram / KW.

→ II^nd law

When same amount of ~~current~~ electricity pass through different electrolyte connected in series equivalent then amount of substance deposited is directly proportional to equivalent weight.



- In Series; current (I) will be same.
- Mass at Cu deposite → depends upon => equivalent wt. at Cu
  Mass ~~of~~ of Ag deposite → depends upon => equivalent wt. of Ag.
- $M_1 = Z_1 Q$ } Q = Same
  $M_2 = Z_2 Q$ }
  So; mass of deposite depends upon values of Z.

$$\boxed{M \propto Z}$$

$$\frac{M_1}{M_2} \propto \frac{Z_1}{Z_2} \Rightarrow \boxed{\frac{M_1}{M_2} = \frac{Z_1}{Z_2}}$$

⇒ Characteristics of Battery :-

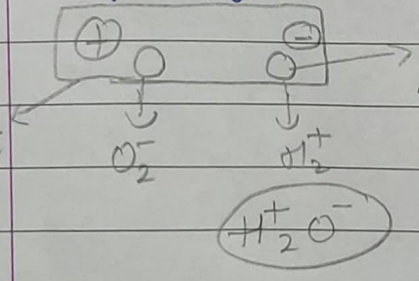
- Voltage → +ve
- Capacity → amp-hour
- Specific Energy → watthour / kg
- Specific Power → watt / kg.
- Temperature Dependence.

→ Indication of Fully charged Battery :-
overcharging / undercharging → Harmful for Battery.

(i). voltage = Termind of cell indicates battery is fully charged.

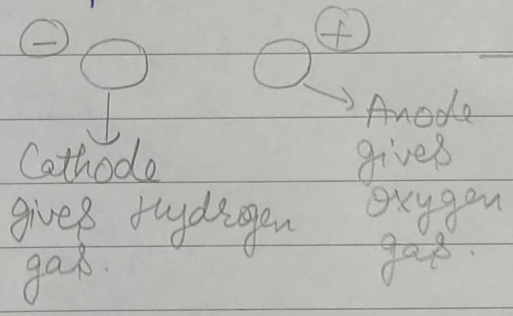
If ⊕ | ⊖ ⇒ Terminal voltage = 2.1 volt ⇒ means Battery is fully charged.

(ii). Specific Gravity of Electrolyte =
- Fully charged Battery have always high specific gravity of electrolyte
- 1.28 -> charged Battery Reading.
- Specific Gravity of electrolyte is measured by Hydrometer.



- Hole for escaping gass
- By hole hydrometer can enter into battery.

(iii). Gassing → • When battery is fully charged; the current (I) starts electrolysis of water.

- Gassing start comes out from vent cap.
- 

→ Result of electrolysis

(iv) Colour of Plates =>

- Fully charged Battery [Lead Acid Battery]
- Anode → colour → Dark ~~Black~~ chocolate Brown
- Cathode → Colour → Grey.