Unit 6: Work, Power, Energy and Batteries (Q No. 7 and Q. No. 8)

Part A: Work, Power Energy

Resistance Temperature Coefficient

1. With neat sketch & example, show the effect of change in temperature on resistance of: (a)Metal (b) Insulator (c) Semiconductor (d) Common & Special Alloys.

Pure Metals (Conductors): The conductor has more number of free electrons. When such conductor is connected across some voltage, ions get formed inside it and the electrons which are moving randomly will get aligned in certain direction. At low temperature ions are stationery, but as soon as temperature increases, the unmovable ions gain energy and start oscillating about their mean position. More the temperature more will be the magnitude of oscillation. This will cause obstruction to flow of free electrons; which lead to increase in resistance. So in case of conductor, with increase in temperature its resistance will increase. So the conductors have positive temperature coefficient of resistance. Examples: Gold, Silver, Copper etc.

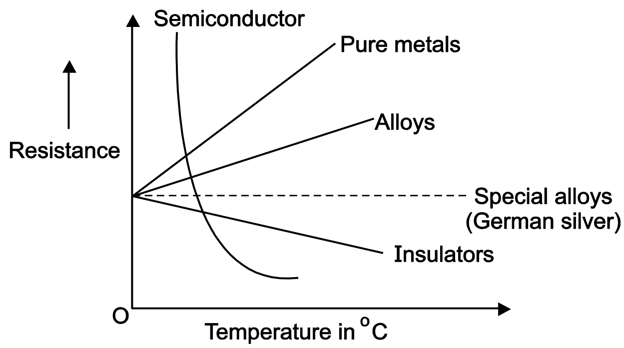


Fig. Variation of Resistance with respect to Temperature

Insulator: In insulator the numbers of free electrons are less. With increase in temperature, vibration of ions will increase. But simultaneously the electrons from the atoms gain extra energy and get escaped from their parent atoms and become available for conduction. This reduces the resistance of insulting material.

So in case of insulator, with increase in temperature, its resistance will decrease. The insulators have negative temperature coefficient of resistance. Examples: Carbon, Mica, Rubber, Plastic etc.

Semiconductor: At low temperature, the resistance of semiconductor is high. But dominant increase in temperature gives additional energy to the electrons available in valency band.

These electrons cross over the narrow energy gap and enters into conduction band. So in case of semiconductor, after certain rise in temperature the resistance drastically reduces to small value and remains constant thereafter

Examples: Silicon, Germenium.

Alloy: The resistance of common alloys such as bronze, brass, steel increases as the temperature increases, but the rate of increase is very small. In special alloys an increase in temperature not only causes an obstruction to the electron movement but also compensates for this by increase in number of free electrons where the number of free electrons is about equal to the obstruction to the thermal energy gained. The temperature change may have very little effect on resistance. e.g. Manganin, Eureka show almost no change in resistance with change in temperature. So such types of alloys are used to make resistance boxes.

2. Define Resistance Temperature Coefficient (RTC) and state the factors on which RTC depends.

RTC is defined as the change in resistance per ohm initial resistance per degree change in temperature.

$$\alpha_o = \frac{R_t - R_o}{R_o t}$$

Unit of RTC $\frac{\text{Ohm}}{\text{Ohm}^o\text{C}} = \frac{\mathbf{1}}{\mathbf{^oC}}$ **or / °C per degree Celsius**

Factors affecting RTC

1) **Type and nature of material:**

   Conductors, general alloys will have positive temperature coefficient

   Insulators and semiconductors will have negative temperature coefficient

   Special alloys, E.g. Eureka, Manganin will have zero temperature coefficient

2) **Temperature:** Change in temperature changes RTC

3. With usual notations derive the expression, $\alpha_2 = \alpha_1 / (1 + \alpha_1 (t_2 - t_1))$.

Let us consider a conducting material whose initial resistance is $\mathbf{R_1}$ at temperature $\mathbf{t_1}$**°C** i.e. at point A

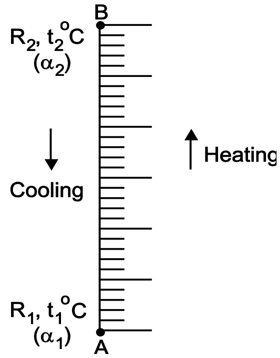


Fig.

Now, if the temperature of heating of the material is gradually increased by heating process up to temperature **t_2°C** i.e. at point B, then it's resistance will be **R_2**

The expression for R_2 ,

$$R_2 = R_1 \left[1 + \alpha_1 \cdot (t_2 - t_1)\right] \qquad \dots (1)$$

Where α_1 is T.C.R. at t_1°C

Now consider that, the material is having resistance R_2 at t_2°C and if the temperature of conducting material is gradually reduced by cooling process up to initial temperature t_1°C i.e. up to point A,

The expression for R_1 ,

$$R_1 = R_2 \left[1 + \alpha_2 \cdot (t_1 - t_2)\right] \qquad \dots (2)$$

where α_2 is T.C.R. at t_2°C.

From equation (1) and (2), taking ratio of

$$\frac{R_1}{R_2} = 1 + \alpha_2 (t_1 - t_2) \qquad \dots (3)$$

$$= \frac{1}{1 + \alpha_1 (t_2 - t_1)} \qquad \dots (4)$$

From equation (3) and (4)

$$\alpha_2 (t_1 - t_2) = \frac{1}{1 + \alpha_1 (t_2 - t_1)} - 1$$

$$= \frac{1 - 1 - \alpha_1 (t_2 - t_1)}{1 + \alpha_1 (t_2 - t_1)} = \frac{- \alpha_1 (t_2 - t_1)}{1 + \alpha_1 (t_2 - t_1)}$$

Multiplying both sides by negative sign and rearranging the equation.

$$\alpha_2 (t_2 - t_1) = \frac{\alpha_1 (t_2 - t_1)}{1 + \alpha_1 (t_2 - t_1)}$$

$$\boldsymbol{\alpha_2 = \frac{\alpha_1}{1 + \alpha_1 (t_2 - t_1)}} \qquad \text{---- (5)}$$

If we consider

$t_1 = 0^oC$ and $t_2 = t^o$ C, $\alpha_1 = \alpha_o$ and $\alpha_2 = \alpha_t$ then,

$$\alpha_t = \frac{\alpha_0}{1 + \alpha_0 t}$$

From equation (5)

$$\alpha_2 + \alpha_1 \alpha_2 \cdot (t_2 - t_1) = \alpha_1$$

$$\boxed{\alpha_1 - \alpha_2 = \alpha_1 \alpha_2 (t_2 - t_1)}$$

Insulation Resistance

4. **What is insulation resistance? State the factors affecting value of Insulation resistance.**

The **insulation resistance** is defined as the resistance offered by an insulating material to the flow of leakage current.

It is denoted by R_i and its unit is Ω.

Mathematically, it is defined as, $R_i = V/I_l$

Where, V = Voltage measured between conductor and earth

I_l = Leakage current and R_i = Insulation resistance.

Factors affecting value of Insulation Resistance

1) Resistivity of the material: Ri depends on type and nature (resistivity) of the material

2) Temperature: As temperature of insulating material increases Ri decreases and vice versa

3) Length: Ri is inversely proportional to the length of the cable

4) Moisture: Ri decreases when the moisture content in insulating material increases.

5. **Derive an expression for insulation resistance of a single core cable.**

To find the resistance offered by insulating material (R_i) of a single core cable having length '*l*' meters to flow of leakage current, cross section of the cable is considered as shown in figure.

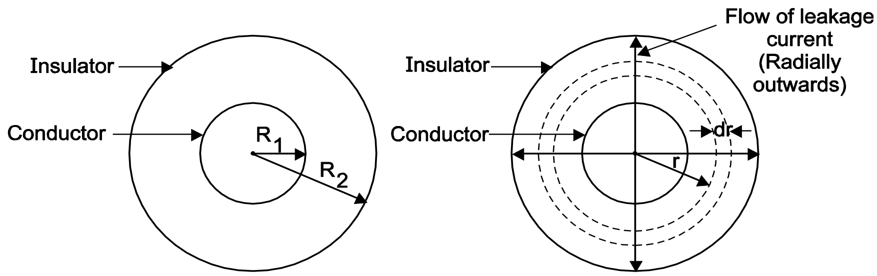


Fig.

Due to finite insulation resistance of the insulating material used, some leakage current flows from the conductor in radialy outward direction. Therefore, to obtain the expression for R_i, a small section with thickness as "*dr*" at a distance of "*r*" meters from the centre of the cable is considered.

Where, R_1 = Radius of conductor, R_2 = Radius of cable including conductor and insulator

Length offered by insulation layer = *dr*, Cross-sectional area = $2\pi rl$

The resistance offered by small section is

$$dR_i = \rho \times \frac{dr}{2\pi r l}$$

The total insulation resistance R_i can be obtained by integrating "dR_i" over the entire radius of insulating material i.e. from R_1 and R_2.

$$R_i = \int_{R_1}^{R_2} dR_i = \int_{R_1}^{R_2} \frac{\rho\, dr}{2\pi r l} = \frac{\rho}{2\pi l}\int_{R_1}^{R_2} \frac{dr}{r} = \frac{\rho}{2\pi l}\left[\log_e r\right]_{R_1}^{R_2}$$

$$R_i = \frac{\rho}{2\pi l}\left[\log_e R_2 - \log_e R_1\right] = \frac{\rho}{2\pi l}\, l_n\left(\frac{R_2}{R_1}\right)\ \Omega$$

$$\boxed{\mathbf{R_i = \frac{\rho}{2\pi l} \log_e\left[\frac{R_2}{R_1}\right]}}\quad \Omega$$

Questions asked in End-Sem Dec 2019 Examination

Q. Define temperature coefficient of resistance. State the factors on which it depends. [4 M] (Refer Q. No.2)

Q. What Prove that $\alpha_2 = \alpha_1/(1 + \alpha_1 (t_2 – t_1))$, all the symbols have their appropriate meaning. [6M] (Refer Q. No. 03)

Unit 06: Work Power Energy and Batteries

Part B: Batteries

1. Explain, what do you mean by Cell and Battery?

Ans: **Cell:** A cell is a basic element of a battery. It consists of two suitable dissimilar metallic plates, called 'electrodes' immersed into a liquid or paste of a certain chemical material, called as 'electrolyte'. The chemical reactions between the electrodes and the electrolyte create a potential difference across the two electrodes. Thus, a cell is an electrochemical device that transforms chemical energy into electrical energy. It can therefore be used as a power source (energy source).

Types of Cells:

A primary cell: The cell, which supplies the energy only once until it is fully discharged is called as the primary cell. It is not rechargeable and hence can be used only once. A Leclanche cell, Voltaic cell, Daniel cell, carbon-zinc cell, zinc chloride cell, silver oxide cell etc. are the examples of primary cells.

A secondary cell: The cell, which can be recharged and used several times is called as a secondary cell. Secondary cells can be acid cells or alkaline cells. A lead-acid cell is a secondary acid cell whereas, a nickel-iron cell and a nickel-cadmium cell are the secondary alkaline cells.

Battery:

A battery consists of a number of identical cells connected together inside a container. As a single cell can develop very small potential difference, the appropriate interconnection of many cells can give a sufficient value of potential difference, which can be useful for practical applications. The cells in a battery may be connected in series, parallel or series-parallel combinations depending on what voltage and current output is required from a battery. The series combination of cells increases the voltage whereas; the parallel combination increases the current delivering capacity.

2. Explain series, parallel and series parallel grouping of cells.

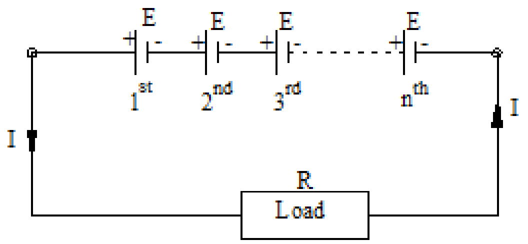
Series Grouping

If n= no. of cells,

r = Internal resistance of the cell

E= EMF of each cell

R= Resistance of the load



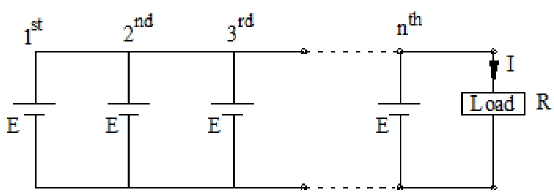
Total EMF of the battery = n × E

Total internal resistance of battery = n × r

Total resistance of circuit = R + n r

Current delivered by battery (I) = $nE/(R+nr)$

Parallel Grouping



Equivalent resistance all cells

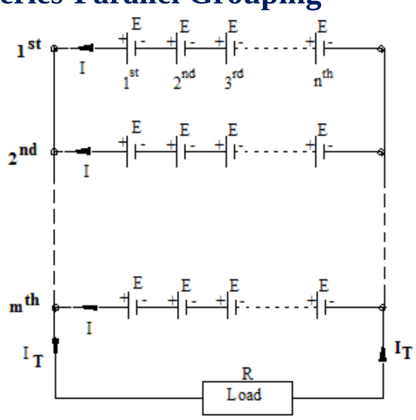
$$= \frac{1}{\frac{1}{r}+\frac{1}{r}+\frac{1}{r}+........+\frac{1}{r}(n\,times)} = \frac{1}{\left(\frac{n}{r}\right)} = \frac{r}{n}$$

Total resistance of circuit $= R + \frac{r}{n}$

Current delivered by battery (I) = $\frac{E}{R+\frac{r}{n}}$

$$= \frac{nE}{nR+r}$$

Series-Parallel Grouping



Equivalent resistance all cells = $(n\ r)/m$

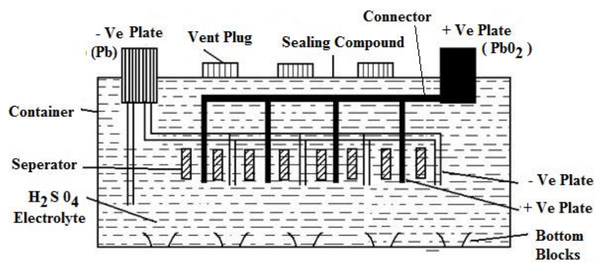
Total resistance of the circuit =$[R+(n\ r/m)]$

Total EMF of the battery = n × E

Current delivered by battery (I_T) = $\frac{nE}{R+(n\ r/m)}$

3. Explain the construction of Lead acid battery with neat diagram

The lead-acid cell essentially contains following elements:



1. Plates

The plates, which are actually electrodes are

a) Anode: Lead Peroxide (PbO_2) of Chocolate brown colour

b) Cathode: Spongy Lead (Pb) with slate grey colour

2. Electrolyte:

Aqueous solution of Sulphuric acid (H_2SO_4).

3. Separators:

The separators are used to separate positive and negative plates, preventing them to come in contact with each other. These are made of either specially treated wood or perforated rubber. The common separator is wood, since it is the cheapest of all separators.

4. Container

The container is made of vulcanized rubber, or glass. Glass containers are normally used for light duty work and rubber container for portable work. Entire assembly of plates along with the solution is placed in the container.

5. Bottom Blocks

These are fitted at the bottom of the container to prevent short circuiting of cell due to the active material fallen from the plates.

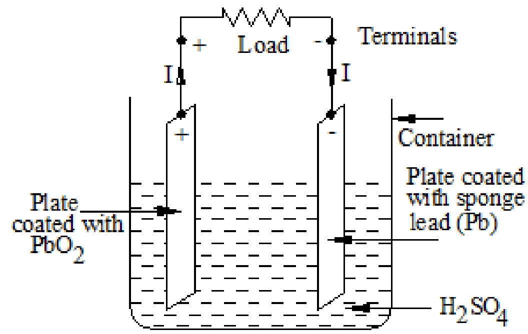
6. Plate connector

Separate connectors are used to connect all positive plates to one bar and negative plates to another common bar

7. Cover with vent Plug

The covers are generally of vulcanized rubber. A hole is provided for pouring the electrolyte and this can be closed by a screwed cap. The cap is provided with minute holes for gases to escape. This is also known as 'Vent Cap'. The function of the vent cap is to allow the escape of the gases.

4. Write down the chemical reactions during first charging and discharging of lead acid battery.



A lead acid battery uses lead acid cells. A lead acid cell is a secondary cell. It is also a wet cell. The basic cell of a lead acid battery is shown below.

Chemical action: When the load is connected across the battery terminals, current starts flowing in the circuit. The electrons leave the –ve plate, pass through the load and come to +ve plate. On the surface of the anode, a molecule of lead peroxide (PbO_2) is dissociated as three ions, one of lead and two of oxygen. The lead ion has a deficiency of two electrons while each oxygen ion has two excess electrons. Thus the anode has deficiency of two electrons. This is as if the anode has two excess +ve charges. This makes the plate +vely charged. In the electrolyte, two molecules of H_2SO_4 are dissociated as four hydrogen ions and two sulfate ions. Every hydrogen ion has deficiency of one electron and every sulfate ion has two surplus electrons. The four hydrogen ions of electrolyte combine with two ions of oxygen to form two molecules of water and one sulfate ion of the electrolyte combines with the lead ion on the positive plate to form $PbSO_4$.

On the surface of negative plate, one atom of lead becomes a positive ion of lead leaving two electrons on the plate. This positive lead ion combines with one sulfate ion of electrolyte to form $PbSO_4$.

Thus, the anode has two excess positive charges and the cathode has two excess negative charges. The negative charges on –ve plate come to the +ve plate through external load circuit and hence the path of current is completed. The current is maintained till the chemical reactions are continued.

The chemical reactions are summarized as;

Dissociation:

At anode: $PbO_2 \Rightarrow Pb^{++}, O^{--}, O^{--}, +e, +e$

In electrolyte: $2(H_2SO_4) \Rightarrow H^+, H^+, H^+, H^+, SO_4^{--}, SO_4^{--},$

At cathode: $Pb \Rightarrow Pb^{++}, e^-, e^-$

Overall Reaction:

$$\mathbf{PbO_2 + 2(H_2SO_4) + Pb \leftrightarrow 2PbSO_4 + 2H_2O}$$

The consequence of these reactions is that, $PbSO_4$ is accumulated on both the plates and the electrolyte changes to water. When all the lead peroxide on +ve plate and lead coating on the –ve plate get converted to $PbSO_4$ and all the H_2SO_4 gets converted to water, the chemical reaction ends and the battery is totally discharged.

Recharging: A d.c. supply of appropriate voltage is given to the cell for an appropriate period of time. This reverses the direction of current within the cell from that while discharging. The chemical reactions are now reversed and the conditions are restored in the cell i.e., the PbO_2 is accumulated on +ve plate, Pb is accumulated on –ve plate and H_2SO_4 is formed again. The battery is now fully charged to use again.

5. What are the indications of fully charged Lead acid battery

The various indications of fully charged battery are

a) Voltage
b) Specific Gravity of Electrolyte
c) Colour of the electrodes
d) Gassing

Voltage: When the cell is fully charged its terminal potential will be approximately 2.6 volts.

Specific Gravity: When the cell is fully charged, the specific gravity of the electrolyte will be approximately 1.21. When the cell is fully discharged its value falls to 1.17.

Colour of Electrodes: When the cell is fully charged, the lead sulphate anode gets converted into lead per oxide (PbO_2) dark chocolate brown in colour and lead sulphate cathode gets converted into lead (Pb), grey in colour. It is considered one of the best tests for ascertaining the condition of a battery

Gassing: When the cell is fully charged, the hydrogen and oxygen gases are liberated at the cathode and anode respectively, so liberation of gases (hydrogen and oxygen), known as gassing, on the electrodes indicates that the cells are fully charged.

6. Describe the maintenance procedure of Lead acid battery

1. The battery should be recharged immediately after discharge i.e., when output voltage is lowered from the permissible value.
2. The electrolyte level in the cells must always be kept above top of the electrodes (plates). Any loss of level (due to evaporation and decomposition) must be compensated by adding pure and distilled water. The ordinary tap water must not be used.
3. The specific gravity of electrolyte must be checked during each charging. If the electrolyte is to be added, it should be pure.
4. The battery should not be left in the discharged condition for longer period, as it reduces the life of battery.
5. The discharged battery should be protected from low temperatures to prevent the electrolytes from freezing and bursting the cell container.
6. The battery should not be overcharged as it can weaken the plate structure of the cells.
7. A battery like a lead-acid battery contains sulfuric acid. Such a battery should be handled and transported carefully as the leakage of acid can cause damage to skin or eyes.
8. A battery should be charged in a well-ventilated space free from flames or sparks, as the gases released during charging are explosive.
9. The terminals of the battery should be kept clean to avoid corrosion and to prevent increase in contact resistance. A thin layer of Vaseline or petroleum jelly should be applied over the terminals.
10. A battery should be overcharged after every 3 to 4 months to wipe out the traces of impurities on the electrode plates. If this is not done, the internal resistances of the cells increase.

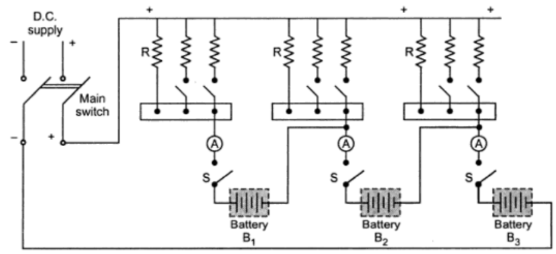
7. State necessary precautions to be taken during charging, handling and maintenance of lead acid battery.

1. Store or recharge lead-acid batteries in a well-ventilated area away from sparks or open flames.
2. Wear acid-resistant goggles/face shield, gloves, and if available, an apron, when recharging or handling lead-acid batteries.
3. Keep lead-acid battery vent caps securely in place.
4. Never overcharge a lead-acid battery and only refill fluid with distilled water.
5. Never attempt to short-circuit a battery. Doing so can damage the product and generate heat that can cause burns.
6. Never attempt to charge a battery which has been physically damaged
7. Do not keep any inflammable liquid like Petrol near the battery.
8. Do not place any metal objects like screwdriver or spanner on the battery. This may cause shorting of terminals.
9. Do not wear metal bangle / metal wear in hand to prevent shorting/burning.
10. The connectors should be firmly attached to the battery terminals.

8. Explain the methods of charging the storage batteries

There are mainly two types of charging namely constant voltage charging and constant current charging:

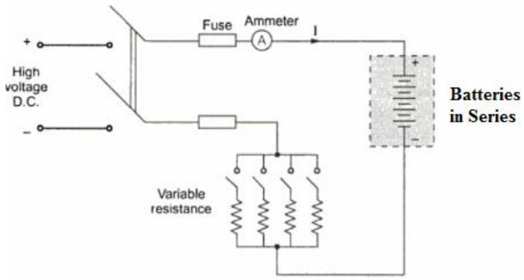
a) Constant Voltage Charging



In this method, the charging voltage is kept constant throughout the charging process. In this method the charging current is high in the beginning when a battery is in discharged condition, and it gradually drops off as the battery picks up charge resulting in increased back emf. Charging at constant voltage may be carried out only when the batteries have the same voltage, for example, 6 or 12 or 24 V. In this case source of current should have a voltage of 7.5, 15 or 30 V; these batteries are connected in parallel to the charging circuit.

This method is the most common method of charging lead- acid batteries and has been used successfully for over 50 years for different types of lead-acid batteries. With this method of charging, the charging time is almost reduced to half, capacity is increased by approximately 20% but efficiency is reduced by approximately 10%.

b) Constant Current Charging



In this method of charging of batteries, the batteries are connected in series so as to form groups and each group is charged from the dc supply mains through loading rheostats. The number of batteries in each group depends on the charging circuit voltage which should not be less than 2.7 V per cell. The chaining current is kept constant throughout the charging period by reducing the resistance in the circuit as the battery voltage goes up. This method is usually employed for initial charging of lead-acid batteries and for charging portable batteries in general.

In order to avoid excessive gassing or overheating, the charging may also be carried out in two steps, an initial charging of comparatively higher current and a finishing rate of low current. In this method the charge current is kept one-eighth of its ampere-hour rating.

9. What is battery efficiency and how it is expressed or calculated?

Efficiency of batteries:

The efficiency of a secondary battery is expressed in two ways namely;

i. Ampere-hour efficiency

ii. Watt-hour efficiency (energy efficiency)

Ampere-hour efficiency is the ratio of output ampere-hours during discharging to the input ampere-hours during charging.

Ampere-hour efficiency (η_{Ah}) **=**

$$\frac{Ampere-hours\,(Ah)\ during\ discharging}{Ampere-hours\,(Ah)\ during\ charging}\,x100$$

$$= \frac{I_d\, xT_d}{I_C\, xT_C}\,x100$$

Where I_d, T_d are the current and time during discharging and I_c, T_c are the current and time during charging. Ampere-hour efficiency of lead-acid cell is about 90%.

Watt-hour efficiency is the ratio of output watt-hours during discharging to the input watt-hours during charging.

Watt-hour efficiency (η_{Wh}) **=**

$$\frac{Energy\ during\ discharging}{Energy\ during\ charging}\,x100 =$$

$$\frac{Watt-hour\,(Wh) during\ discharging}{Watt-hour\,(Wh)\ during\ charging}\,x100$$

$$= \frac{I_d\, xT_d xV_d}{I_C\, xT_C xV_C}\,x100$$

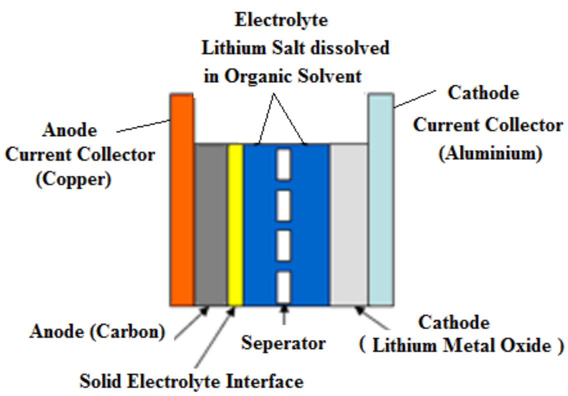
Where I_d, T_d and V_d are the current, time and average *pd* during discharging. And I_c,

T_c and V_c are the current, time and average *pd* during charging.

Watt-hour efficiency of lead-acid cell is ranges from 75% to 90%.

10. Explain construction of Lithium Ion battery.

The lithium ion battery was introduced in the early 1990s. This batteries consist of largely four main components: cathode, anode, electrolyte, and separator.



a) **Cathode:** A Positive electrode is made with Lithium Cobalt Oxide ($LiCoO_2$) has a current collector made of thin aluminum foil.

b) **Anode:** A negative electrode made with specialty carbon has current collector of thin copper foil.

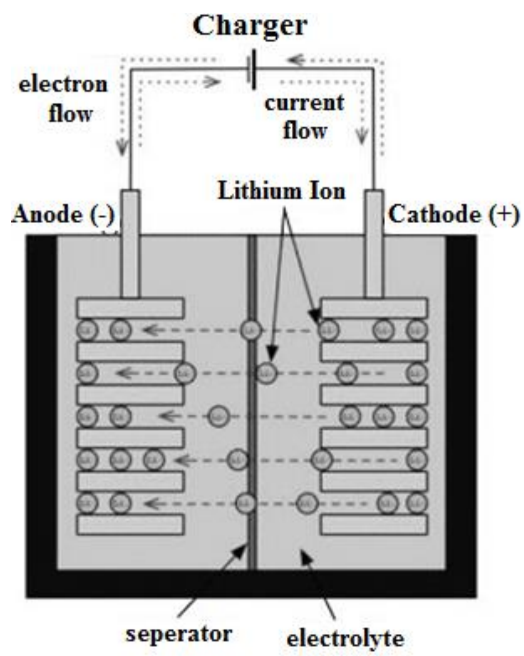
c) **Separator:** It is a fine porous polymer film.

d) **Electrolyte:** Lithium salt in an organic solvent. Electrolyte is selected in such a way that there should be an effective transport of Li-ion to the cathode during discharge. Type of conductivity is ionic in nature rather than electronic.

11. Explain working of Lithium Ion battery along with charging and discharging equations.

As their name suggests, lithium-ion batteries are all about the movement of lithium ions: the ions move one way when the battery charges (when it's absorbing power); they move the opposite way when the battery discharges (when it's supplying power):

Charging

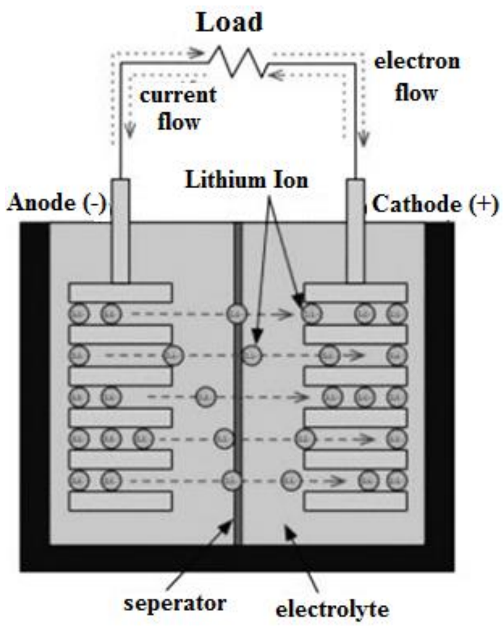


Battery Charging

During charging, lithium ions flow from the positive electrode to the negative electrode through the electrolyte. Electrons also flow from the positive electrode to the negative electrode, but take the longer path around the outer circuit. The electrons and ions combine at the negative electrode and deposit lithium there.

When no more ions will flow, the battery is fully charged and ready to use.

Discharging



Battery Discharging

During discharging, the ions flow back through the electrolyte from the negative electrode to the positive electrode. Electrons flow from the negative electrode to the positive electrode through the outer circuit, powering the load. When the ions and electrons combine at the positive electrode, lithium is deposited there.

When all the ions have moved back, the battery is fully discharged and needs charging up again

At Cathode (+):

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

At Anode (-):

$$C_n + xLi^+ + xe^- \underset{discharge}{\overset{charge}{\rightleftharpoons}} C_nLi_x$$

Overall reaction:

$$LiCoO_2 + C_n \underset{discharge}{\overset{charge}{\rightleftharpoons}} C_nLi_x + Li_{1-x}CoO_2$$

12. State applications of Lead acid and Lithium ion battery.

Lead Acid Battery:

1. Used in automobiles for starting and lighting
2. Used in generating stations and Substations to operate protective devices and emergency lighting
3. Used Un-interrupted Power Supply (UPS)
4. Used in Emergency Lighting
5. Used in telephone exchange

Lithium Ion Battery

1. Used in mobile phones, Laptops
2. Used in cameras and calculators
3. Used in Electric vehicles
4. Used in toys and rechargeable flash lights
5. Used in aerospace applications.

13. Compare Lead Acid and Lithium ion battery

	Lead Acid	Lithium Ion

Anode	PbO_2	$LiCoO_2$
Cathode	Pb	Carbon
Electrolyte	H_2SO_4	Lithium salt with organic solvent
Specific power	180 W/kg	340 W/kg
Specific Energy	50 Wh/kg	265 Wh/kg
Energy density	50-100 Wh/m^3	690 Wh/m^3
Cycle life	200-300 cycles	1200 Cycles
Cost	Low cost	Costly
Rated Voltage	2.2 Volt	3,6 Volt
Maintenance	Maintenance required	Maintenance free
Charging	Slow and inefficient	Fast charging
Handling	Difficult	Easy
Use	Car, motorcycle, UPS, Emergency lighting	Mobile phone, Laptop, Camera, Electric vehicles

14. Explain Concept of Depth of Discharging (DoD)

DoD is the key factor for any battery. It indicates the degree to which the battery can be discharged to certain minimum voltage from its full state of charge.

Though the battery capacity is specified by the manufacturer, it is not possible to use it at its entire capacity. The DoD gives the indication that, upto which level of discharge the battery capacity can be used safely.

DoD is defined as the capacity in Ah that is discharged from a fully charged battery, divided by battery nominal capacity. DoD is normally expressed in percent (%).

When the battery is discharged to its full energy capacity, then its DoD is 100%.

DoD is important because the life span of batteries such as lead acid, lithium ion depends heavily on no. of charge and discharge cycles. If DoD is high, then the life span of the battery gets shortened. e.g. a battery may have 5000 cycles at 20% DoD, but 1500 cycles at 80 % DoD.

Lithium ion batteries typically be discharged upto 80% before reaching a potential harmful state of deep discharge. They have a battery management system to prevent deep discharge.

Most battery manufacturers indicate in the specification sheet, the maximum recommended DoD for peak performance of the battery. If the manufacturer of 20 kWh battery recommends a maximum DoD of 60 %, it means that you should avoid discharging more than 12 kWh without recharging.