UNIT-V

SOLAR PHOTOVOLTAIC SYSTEMS

ESSAY QUESTIONS

Q. 2. What is electric battery? How it works?

An electric battery is a source of electric power consisting of one or more electrochemical cells with external connections for powering electrical devices. When a battery is supplying power, its positive terminal is the cathode and its negative terminal is the anode.The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy.

Primary (single-use or "disposable") batteries are used once and discarded, as the electrode materials are irreversibly changed during discharge; a common example is the alkaline battery used for flashlights and a multitude of portable electronic devices. Secondary (rechargeable) batteries can be discharged and recharged multiple times using an applied electric current; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics such as laptops and mobile phones. Batteries have much lower specific energy (energy per unit mass) than common fuels such as gasoline. In automobiles, this is somewhat offset by the higher efficiency of electric motors in converting electrical energy to mechanical work, compared to combustion engines.

Working principle :

Batteries convert chemical energy directly to electrical energy. In many cases, the electrical energy released is the difference in the cohesiveor bond energies of the metals, oxides, or molecules undergoing the electrochemical reaction. For instance, energy can be stored in Zn or Li, which are high-energy metals because they are not stabilized by d-electron bonding, unlike transition metals. Batteries are designed so that the energetically favourable redox reaction can occur only when electrons move through the external part of the circuit.

A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing metal *cations*. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode, to which cations (positively charged ions) migrate. Cations are reduced (electrons are added) at the cathode, while metal atoms are oxidized (electrons are removed) at the anode.[19] Some cells use different electrolytes for each half-cell; then a separator is used to prevent mixing of the electrolytes while allowing ions to flow between half-cells to complete the electrical circuit.

Each half-cell has an electromotive force (*emf*, measured in volts) relative to a standard. The net emf of the cell is the difference between the emfs of its half-cells. Thus, if the electrodes in other words, the net emf is the difference between the reduction potentials of the half-reactions.

The electrical driving force across the terminals of a cell is known as the *terminal voltage (difference)* and is measured in volts. The terminal voltage of a cell that is neither charging nor discharging is called the open-circuit voltage and equals the emf of the cell. Because of internal resistance, the terminal voltage of a cell that is discharging is smaller in magnitude than the open-circuit voltage and the terminal voltage of a cell that is charging exceeds the open-circuit voltage. An ideal cell has negligible internal resistance, so it would maintain a constant terminalvoltage of until exhausted, then dropping to zero. If such a cell maintained 1.5 volts and produce a charge of one coulomb then on complete discharge it would have performed 1.5 joules of work. In actual cells, the internal resistance increases under discharge and the open-circuit voltage also decreases under discharge. If the voltage and resistance are plotted against time, the resulting graphs typically are a curve; the shape of the curve varies according to the chemistry and internal arrangement employed.

The voltage developed across a cell's terminals depends on the energy release of the chemical reactions of its electrodes and electrolyte. Alkaline and zinc–carbon cells have different chemistries, but approximately the same emf of 1.5 volts; likewise NiCd and NiMH cells have different chemistries, but approximately the same emf of 1.2 volts. The high electrochemical potential changes in the reactions of lithium compounds give lithium cells emfs of 3 volts or more.

Almost any liquid or moist object that has enough ions to be electrically conductive can serve as the electrolyte for a cell. As a novelty or science demonstration, it is possible to insert two electrodes made of different metals into a lemon, potato, etc. and generate small amounts of electricity.

A voltaic pile can be made from two coins (such as a nickel and a penny) and a piece of paper towel dipped in salt water. Such a pile generates a very low voltage but, when many are stacked in series, they can replace normal batteries for a short time.

Q. 5. *Write description about Molten solvent batteries.*

Molten-salt batteries are a class of battery that uses molten salts as an electrolyte and offers both a high energy density and a high power density. Traditional non-rechargeable thermal batteries can be stored in their solid state at room temperature for long periods of time before being activated by heating. Rechargeable liquid-metal batteries are used for industrial power backup, special electric vehicles and for grid energy storage, to balance out intermittent renewable power sources such as solar panels.

Since the mid-1960s much development work has been undertaken on rechargeable batteries using sodium (Na) for the negative electrodes. Sodium is attractive because of its high reduction potential of "2.71 volts, low weight, relative abundance, and low cost. In order to construct practical batteries, the sodium must be in liquid form. The melting point of sodium is 98 °C (208 °F). This means that sodium-based batteries operate at temperatures between 245 and 350 °C (470 and 660 °F).[5] Research has investigated metal combinations with operating temperatures at 200 °C (390 °F) and room temperature.

Rechargeable configurations :

Sodium–Sulphur :

The sodium–sulphur battery (NaS battery), along with the related lithium–sulphur battery employs cheap and abundant electrode materials. It was the first alkali-metal commercial battery. It used liquid sulphur for the positive electrode and a *ceramic* tube of beta-alumina solid electrolyte (BASE). Insulator corrosion was a problem because they gradually became conductive, and the self-discharge rate increased.

(i) Capacity: 25–250 kWh per bank.

(ii) Efficiency of 87%.

(iii) Lifetime of 2,500 cycles at 100% depth of discharge (DOD), or 4,500 cycles at 80% DOD.

Sodium–nickel chloride (Zebra) battery :

The Na-$NiCl_2$ battery operates at 245 °C (473 °F) and uses molten sodium tetra chloroaluminate ($NaAlCl_4$), which has a melting point of 157 °C (315 °F), as the electrolyte. The negative electrode is molten sodium. The positive electrode is nickel in the discharged state and nickel chloride in the charged state. Because nickel and nickel chloride are nearly insoluble in neutral and basic melts, contact is allowed, providing little resistance to charge transfer. Since both $NaAlCl_4$ and Na are liquid at the operating temperature, a sodium-conducting â-alumina ceramic is used to separate the liquid sodium from the molten $NaAlCl_4$. The primary elements used in the manufacture of these batteries have much higher worldwide reserves and annual production than lithium.

Liquid-metal batteries :

Liquid-metal rechargeable batteries, using both magnesium–antimony and more recently lead–antimony. The electrode and electrolyte layers are heated until they are liquid and self-segregate due to density and immiscibility. Such batteries may have longer lifetimes than conventional batteries, as the electrodes go through a cycle of creation and destruction during the charge–discharge cycle, which makes them immune to the degradation that afflicts conventional battery electrodes.

Thermal batteries (non-rechargeable) :

Thermal batteries use an electrolyte that is solid and inactive at ambient temperatures. They can be stored indefinitely provide full power in an instant when required. Once activated, they provide a burst of high power for a short period (a few tens of seconds to 60 minutes or more), with output ranging from watts to kilowatts. The high power is due to the high ionic conductivity of the molten salt (resulting in a low internal resistance), which is three orders of magnitude (or more) greater than that of the sulfuric acid in a lead–acid car battery.

One design uses a fuse strip (containing barium chromate and powdered zirconium metal in a ceramic paper) along the edge of the heat pellets to initiate the electrochemical reaction. The fuse strip is typically fired by an electrical igniter or squib which is activated with an electric current.

Another design uses a central hole in the middle of the battery stack, into which the high-energy electrical igniter fires a mixture of hot gases and incandescent particles. This allows much shorter activation times (tens of milliseconds) vs. hundreds of milliseconds for the edge-strip design. Battery activation can be accomplished by a percussion primer, similar to a shotgun shell. The heat source should be gasless. The higher the potassium perchlorate level, the higher the heat output (nominally 200, 259, and 297 cal/g respectively). This property of unactivated storage has the double benefit of avoiding deterioration of the active materials during storage and eliminating capacity loss due to self-discharge until the battery is activated.

Uses :

Thermal batteries are used almost exclusively for military applications, notably for guided missiles.They are the primary power source for many missiles such as the AIM-9 Sidewinder, AIM-54 Phoenix, MIM-104 Patriot, BGM-71 TOW, BGM-109 Tomahawk and others. In these batteries the electrolyte is immobilized when molten by a special grade of magnesium oxide that holds it in place by capillary action. This powdered mixture is pressed into pellets to form a separator between the anode and cathode of each cell in the battery stack. As long as the electrolyte (salt) is solid, the battery is inert and remains inactive. Each cell also contains a pyrotechnic heat source, which is used to heat the cell to the typical operating temperature of 400–550 °C.

Q. 8. *What is a Super capacitor? Explain its working and give applications?*

Super capacitor :

supercapacitor also called as ultracapacitor or a high-capacity capacitor or double-layer electrolytic capacitor that can store large amounts of energy nearly 10 to 100 times more energy when compared to the electrolytic capacitors. It is widely preferred than batteries because of its faster charging capacity and faster delivery of energy. It has more charging and discharging cycles than rechargeable batteries. These are developed in modern times for industrial and economic benefits. The capacitance of this capacitor is also measured in Farad's (F). The main advantage of this capacitor is its efficiency and high-energy storage capacity.

Working of Super capacitor : Similar to a normal capacitor, the supercapacitor also has two parallel plates with a bigger area. But the difference is, the distance between the plates is small. The plates are made up of metals and soaked in electrolytes. The plates are separated by a thin layer called an insulator.

Fig : Super capacitor-symbol

When opposite charges are formed on both sides of the insulator, an electric double layer is formed and the plates are charged. Hence the super capacitor is charged and has higher capacitance. These capacitors are used to provide high power and enable high load currents with low resistance. The cost of the super capacitor is high because of its high charging and discharging capacitance.

An electric-double layer is created when the plates are changed and opposite charges are formed on both sides of the plates. Hence the supercapacitors are also called double-layer capacitors or electric double-layer capacitors (EDLC'S). When the area of the plates increases and the distance between the plates decreases, then the capacitance of the capacitor increases.

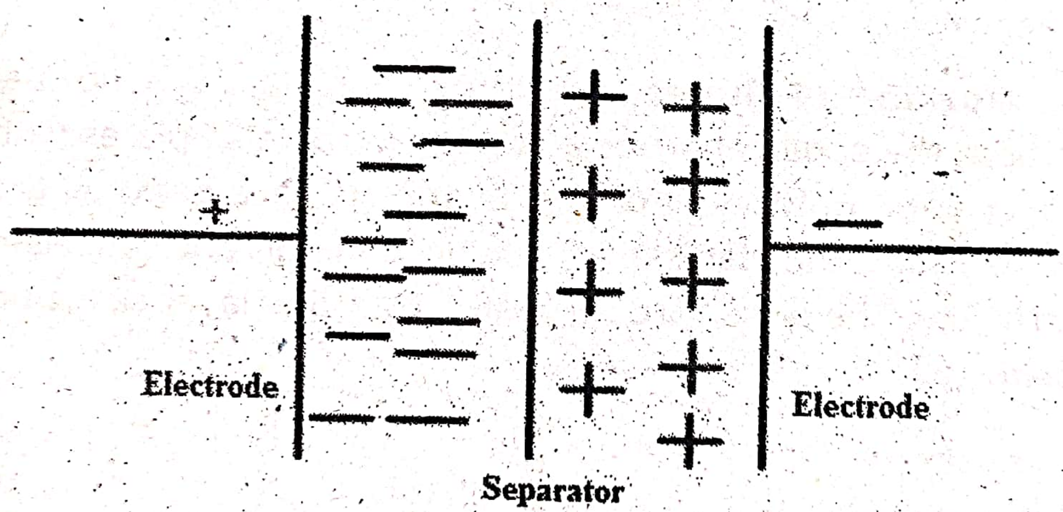


Fig : Super capacitor-working

When the super capacitor is not charged, all the charges are distributed randomly within the cell. When the supercapacitor is charged, all the positive charges are attracted to the negative terminal and negative charges are attracted to the positive terminal. Generally, super capacitors are available with 420F capacitance, charging and discharging current 4-2Amps with a room temperature of -22 degrees centigrade.

Charging of a Super capacitor :

The super capacitor has the self-discharging capacity and unlimited charging-discharging cycles. These types of capacitors can work with low voltages (2-3 volts) and can be connected in series to produce high voltage, which is used in powerful equipment. It can store more energy and releases instantly and more quickly when compared to batteries.

When this capacitor is connected to the circuit or DC voltage source, the plates are charges and opposite charges are formed on both sides of the separator, which forms a double-layer electrolytic capacitor.

To charge a super capacitor, connect the positive side of the voltage source to the positive terminal of the super capacitor and the negative side of the voltage source is connected to the negative terminal of the supercapacitor.

If the super capacitor is connected to 15 volts voltage source, then it charges up to 15 volts. As the voltage is increased beyond the applied voltage source, the super capacitor may get damaged. So, the resistor is connected in series with the voltage source and capacitor to decrease the amount of current flowing through the capacitor and it doesn't get damaged.

The constant current supply and limited voltage supply is suitable for the super capacitor. When the voltage is increased gradually, the amount of current flowing through the capacitor changes. In the fully charged mode, the current drops by default.

Applications :

The applications of super capacitor include the following :

(i) To deliver high power and bridge power gaps.

(ii) Industrial and electronic applications.

(iii) Used in wind turbines, electric and hybrid vehicles.

(iv) Regenerative braking to release the power in acceleration.

(v) To start power in start-stop systems.

(vi) Regulate voltage in the energy grid.

(vii) To capture and assist the power in lower loads and lifted loads.

(viii) Back-ups the power in a quick discharging state.

SHORT ANSWER QUESTIONS

Q. 2. Explain about different types of batteries.

They are two types of Primary and secondary batteries :

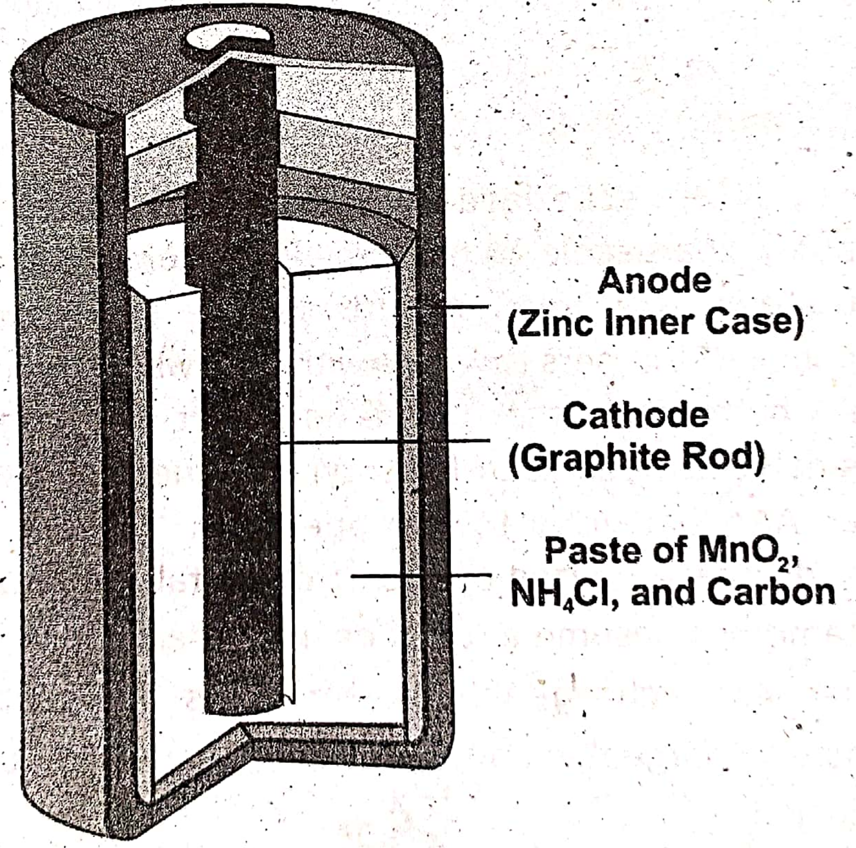
(i) *Primary* batteries are designed to be used until exhausted of energy then discarded. Their chemical reactions are generally not reversible, so they cannot be recharged. When the supply of reactants in the battery is exhausted, the battery stops producing current and is useless.

(ii) *Secondary* batteries can be recharged; that is, they can have their chemical reactions reversed by applying electric current to the cell. This regenerates the original chemical reactants, so they can be used, recharged, and used again multiple times.

Some types of primary batteries used, for example, for telegraph circuits, were restored to operation by replacing the electrodes. Secondary batteries are not indefinitely rechargeable due to dissipation of the active materials, loss of electrolyte and internal corrosion. Primary batteries, or primary cells, can produce current immediately on assembly. These are most commonly used in portable devices that have low current drain, are used only intermittently, or are used well away from an alternative power source, such as in alarm and communication circuits where other electric power is only intermittently available. Disposable primary cells cannot be reliably recharged, since the chemical reactions are not easily reversible and active materials may not return to their original forms. Battery manufacturers recommend against attempting to recharge primary cells. In general, these have higher energy densities than rechargeable batteries, but disposable batteries do not fare well under high-drain applications with loads under 75 ohms (75 Ω). Common types of disposable batteries include zinc–carbon batteries and alkaline batteries.

Q. 3. What is a dry cell battery?

A battery is a gadget comprised of one or more electrochemical cells that convert the stored chemical energy into electrical energy. In today's power savvy world, dry cell is one of many types of electrochemical cells available for consumer use, but it was a great innovation when it was invented. Wet-cell batteries, which came first, were normally delicate glass holders with lead bars swinging from an open top. They required cautious effort to avoid any spillage. This risk level along with many other reasons called for the development of the dry-cell battery. A dry cell contains a paste of immobilized electrolyte, with just the right amount of dampness in it to permit the current to flow seamlessly. In contrast to batteries containing wet cell, a dry cell can work without spilling, since it does not hold free fluid. This makes dry cell batteries the best for use in almost all portable equipment.



Dry cell battery

VERY SHORT ANSWER QUESTIONS

Q. 1. *What is an electrochemical device?*

Electrochemical devices either generate electricity from a chemical reaction (like a battery) or use electrical energy to cause a chemical reaction (like a catalyst).

Q. 2. What is a primary and secondary cell?

A cell that converts chemical energy into electrical energy by irreversible chemical reactions is called primary cell.

A secondary cell or battery is one that can be electrically recharged after use to their original pre-discharge condition, by passing current through the circuit in the opposite direction to the current during discharge.

Q. 3. Why are solid-state batteries better?

A solid-state battery has higher energy density than a Li-ion battery that uses liquid electrolyte solution. It doesn't have a risk of explosion or fire, so there is no need to have components for safety, thus saving more space.

Q. 4. How does molten salt batteries work?

Molten salts are mainly used in reserve batteries in which the electrolyte is in solid state during storage. When the battery is used, the electrolyte is heated and becomes ionically conductive liquid. This kind of batteries can be stored for a very long period but the operating period is short.

Q. 5. What is lead acid battery used for?

They are used in back-up power supplies for alarm and smaller computer systems (particularly in uninterruptible power supplies; UPS) and for electric scooters, electric wheelchairs, electrified bicycles, marine applications, battery electric vehicles or micro hybrid vehicles, and motorcycles.