38. ELECTRIC CELLS

38.1 Electric Current

Everyday application of electricity is through the use of electric current, that is, the flow of electricity along a conductor. To produce this, there must be differences in potential between two points in the system of conduction. As a difference of pressure is necessary at the end of a tube to make water flow through it, similarly, electrical pressure is necessary across the two points on the conductor for the electric current to flow through it.

Every source of current has two poles on which the working of the source has different potential. The one with higher potential is called *the positive pole*, while the other is the *negative pole*. Electrons move through external circuit from the negative to the positive pole, but it is conventional that positive current will pass round the circuit from the positive to the negative pole. The original direction of flow of electric current is taken from the positive point to the negative point of a conductor. This is *conventional current.*

In conductors, the positive charge cannot move, the transfer of charge is only due to the conventional current in a direction opposite to the direction of movement of the electrons. An excitedly small potential difference across any two points of a conductor is sufficient to make these electrons flow through the metal.

In liquids and gases, the positively charged particles actually move in the direction of the conventional current.

38.2 Conductors and Insulators

Substances which allow electricity to flow through them are called *conductors* and those which do not allow the flow of electricity are called *insulators*. Examples of conductors are: (i) metal (ii) organic solution (iii) salt (Aqueous) (iii) acid solution, while examples of insulators are: (i) wood (ii) paper (iii) air (iv) rubber (v) plastic.

The best conductor is silver, and copper is next to it. Alloys are mixture or a combination of impure substances into a definite substance.

Examples of alloy are: (i) nichrome (ii) manganin.

38.3 Electric Cell

An electric cell is a device used to generate the electric force required to move the electrons through the internal and external electric circuit. There are primary and secondary cells.

1. Primary cells: Primary cells are cells that cannot be recharged. They give out electrical energy directly from its stored energy. Examples are: (i) Simple cell (ii) Daniel cell (iii) Leclanche cell.

2. Secondary cells (Accumulators): They are cells which can be recharged and cannot generate electricity until electricity has been supplied to it. Examples are: (i) nickel iron accumulator (ii) lead-acid accumulator.

A simple cell uses copper and zinc plate in dilute tetraoxosulphate (VI) acid. The positive pole is copper, negative pole is zinc and electrolyte is dilute tetraoxosulphate (VI) acid.

Electrodes are two poles through which electrolyte / current enters or leaves the electrolyte. Examples are: (i) copper (ii) carbon (iii) lead (iv) zinc.

Electrolyte is a chemical compound in its aqueous state through which electrons are present. Examples are (i) dilute tetraoxosulphate (VI) acid (ii) solution of ammonium chloride in water.

38.4 Simple Cell [Voltaic Cell]

Simple voltaic cell consists of a glass vessel containing dilute tetraoxosulphate (VI) acid. Two electrodes of copper and zinc are immersed in the electrolyte; the copper rod is positive electrode, while the zinc rod is negative electrode.

When a zinc rod is dipped in dilute tetraoxosulphate (VI) acid, the zinc atoms are absorbed into the solution, forming zinc sulphate and two atoms of hydrogen carrying two units of positive charges. Then more mobile electrons cling to the zinc rod and this makes it negatively charged. After connection, the hydrogen atoms which are positively charged travel towards the copper rod. The movement is from zinc to copper in external circuit. The conventional direction of current is taken as the flow of positive charge from copper to zinc. The e.m.f. of the cell is maintained by fresh zinc ions going into solution.

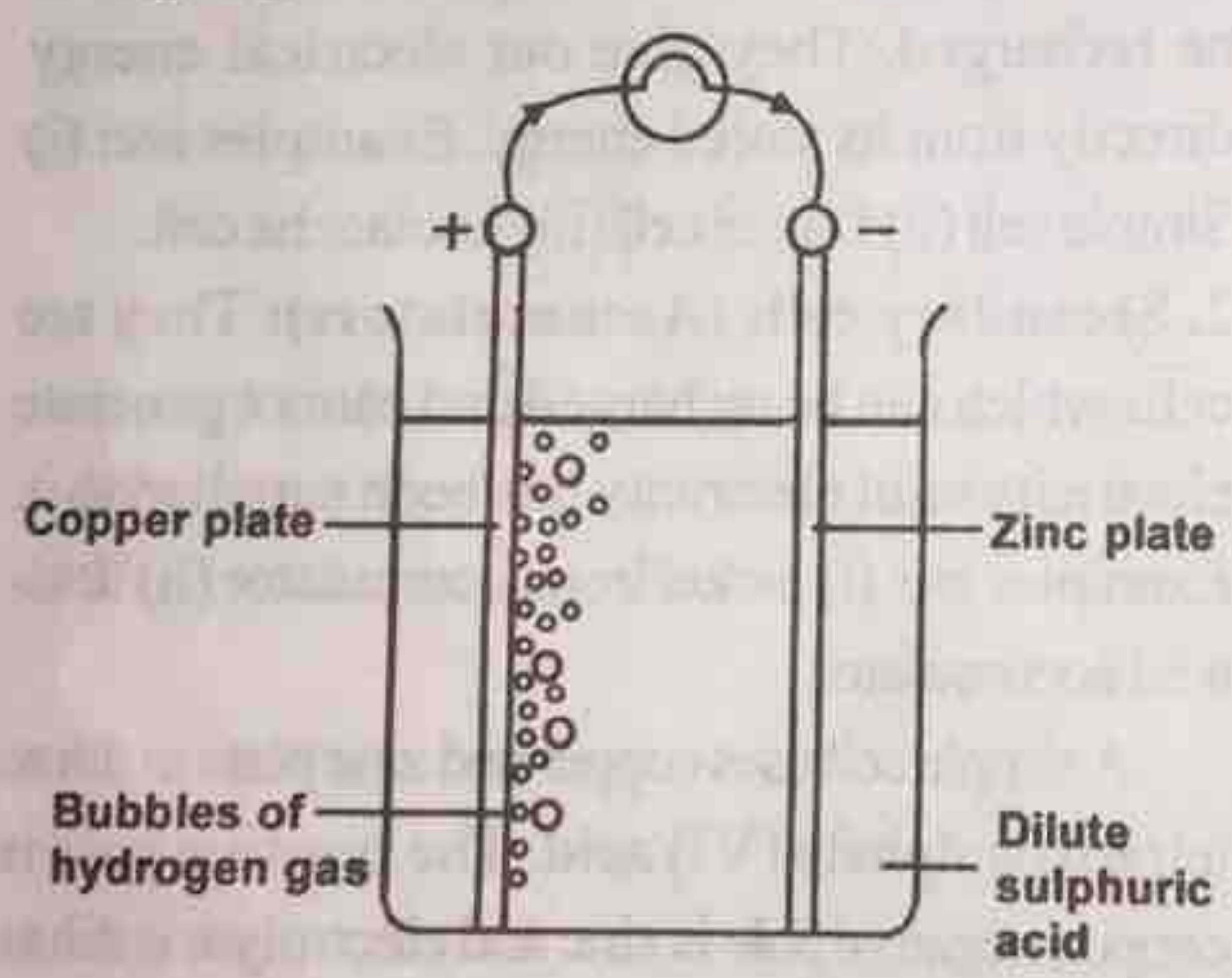

Fig. 38.1 Simple cell

38.5 Electromotive Force [E. M.F]

A potential difference is set up by contact between copper and acid and between zinc and acid due to movement of electric charges. This results in a p.d between copper and zinc. The name *electromotive force* is given when the cell is an open circuit.

38.6 Defects of Simple Cell

The defects of a simple cell are: (i) local action (ii) polarization.

(i) Local action: When impure zinc plates are used in cells, they result in the zinc plates continuing to dissolve even when the cell is not giving out current. Many of these impurities exist on the surface of zinc. They come in contact with acid and minute cells are formed on the zinc rod itself. This defect is called *local action,* and can be reduced by rubbing it with some mercury. Initially, it is washed with hydrochloric acid and then mercury is rubbed on the surface of the rod.

Local action can be prevented by amalgamating the surface of the zinc plate.

(ii) Polarization: When a cell is working, hydrogen gas collected at the positive electrode slows down activity of the cell and even stops its working process. This kind of defect is called *polarization.*

Polarization can be prevented by either brushing the plates or by using depolarizer (an oxidizing agent) which is commonly used in manganese dioxide. This oxidizes hydrogen to form water and helps in removing the hydrogen bubbles.

38.7 Daniel Cell

Daniel cell consists of a copper vessel containing copper sulphate solution. The vessel itself acts as the positive electrode. A porous pot containing dilute tetraoxosulphate (VI) acid is immersed in the copper vessel. An amalgamated zinc rod dipped in the acid serves as the negative electrode (the two are in contact through the porous pot.) The copper sulphate solution contains CU^{2+} and $SO4^{2-}$ ions. Thus the positive ion which are driven on to the copper plate are copper ions instead of hydrogen ion and no layer of hydrogen bubbles is formed on the surface of the plate because polarization is prevented. Daniel cell is not much in use nowadays.

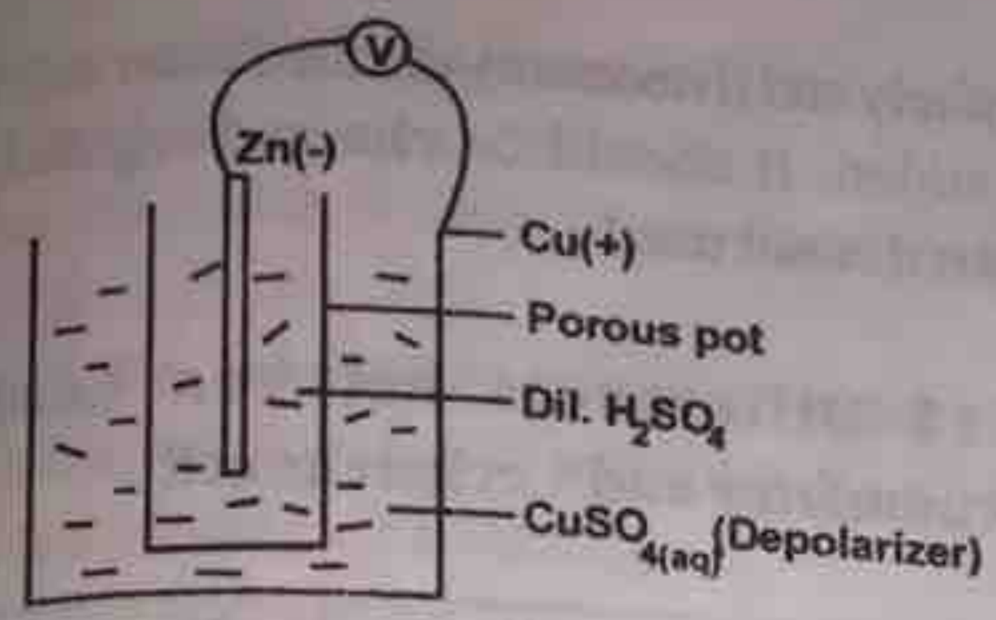

Fig. 38.2 Daniel cell

Advantages of Daniel cell

(i) It has a longer working time.

(ii) It is not affected by polarization.

N.B: The cell has an e.m.f of about 1.1v.

38.8 Leclanche Cell

Leclanche cell has an e.m.f. of about 1.5V. It is made up of: (i) wet Lechanche cell (ii) dry Lechanche cell.

(i) **Wet Leclanche cell:** This consists of zinc rod and the cathode in solution of ammonium chloride enclosed in a vessel. Carbon is used as the anode. The porous pot is surrounded by manganese dioxide as the depolarizer. The zinc, the carbon and the electrolyte set up an electromotive force which drives a current from zinc to carbon through the cell. The carbon has higher potential than the zinc. The current flows through the outside circuit, from carbon to zinc, but it flows through the inside circuit from zinc to carbon. The wet cell experiences two defects: (i) polarization (ii) it is difficult to carry about without spilling the liquid content.

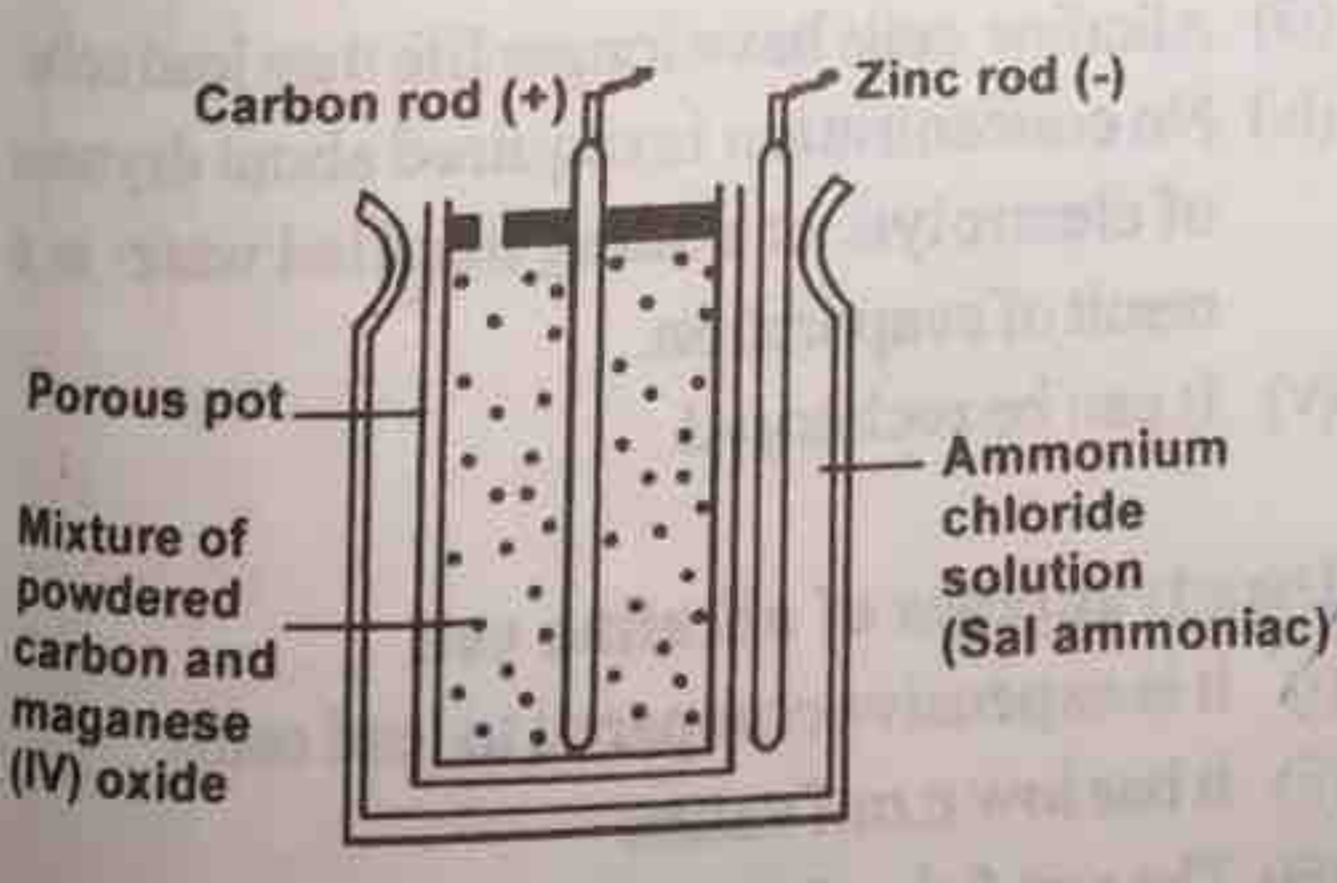

Fig. 38.3 Wet Leclanche cell

(ii) **The dry Leclanche cell:** Dry-Leclanche cell consists of zinc vessel or can (-ve pole) containing jelly or Paste ammonium chloride (NH_4CL). Inside the vessel, there is a bag round the carbon pole (+ve pole) containing a mixture of manganese (IV) oxide with powdered carbon.

Dry Lechanche cell is affected by polarization and local-action, but its advantages are: (i) cheapness of its chemical (ii) portability (iii) relatively high e.m.f.

Polarization by the hydrogen gas is prevented by the manganese oxide as a depolarizer.

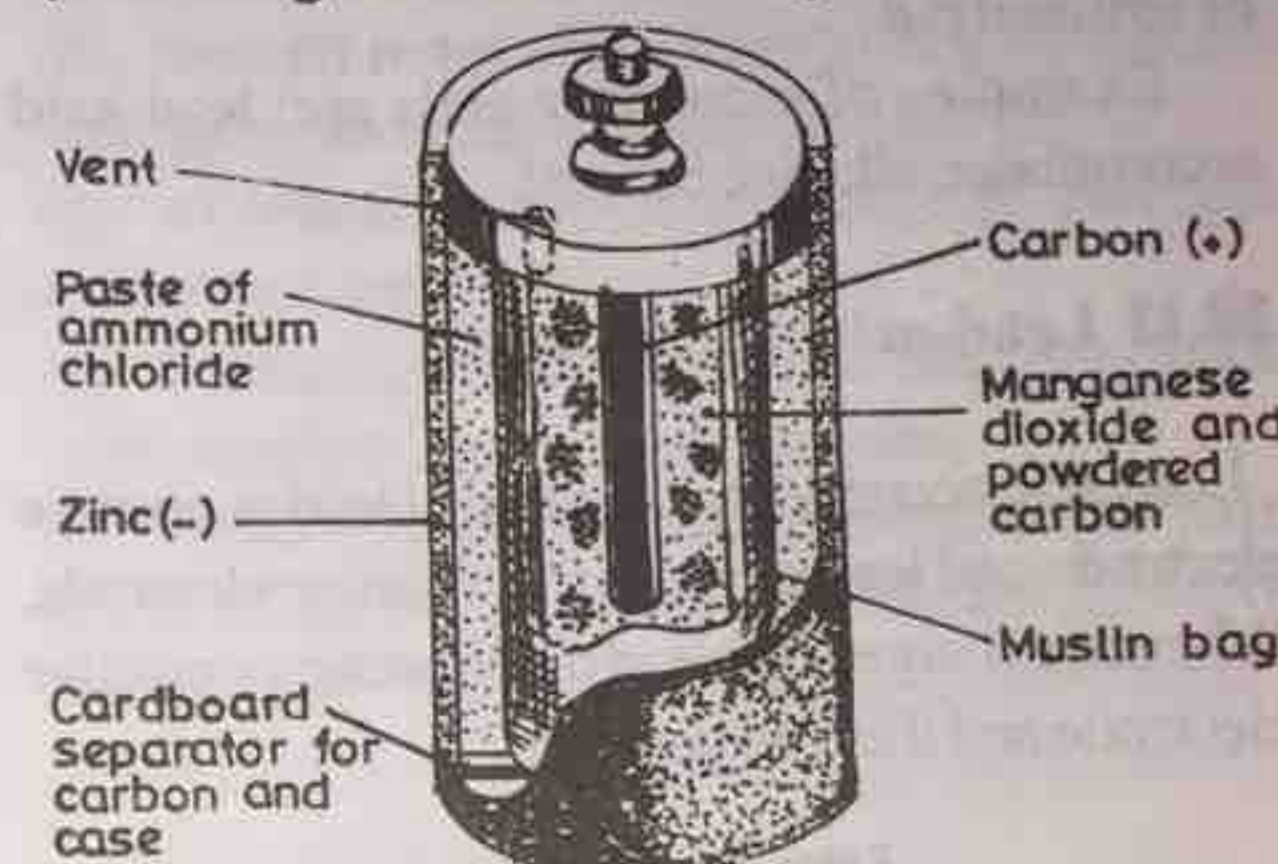

Fig. 38.4 The dry Leclanche cell

Advantages of wet Leclanche cell

(i) The chemical used are very cheap and easily available.

(ii) It gives larger current for short time.

Disadvantages (WET)

(i) The electrolyte evaporates quickly, and thus requires addition of water always.

(ii) It is not suitable for giving long durational current.

38.9 Primary Cells

Primary cells exhibit the following properties:

(i) They are not rechargeable.

(ii) They are affected by defects such as local-action and polarization.

(iii) They have a very high internal resistance and hence can give a small current with very high drop of terminal p.d.

Examples of primary cells are: simple (voltaic) cell, Daniel cell, Leclanche cell etc.

38.10 Secondary Cells

Secondary cells exhibit the following properties:

(i) They are re-chargeable.
(ii) They are not affected by defects such as local-action and polarization.
(iii) They have a very low internal resistance and hence can give a large current with very little drop of terminal p.d.

Examples of secondary cells are: lead-acid accumulator, alkaline cell, etc.

38.11 Lead-acid Accumulator

Lead acid accumulator consists of lead as positive electrode and lead oxide as the negative electrode. When it is charged, the lead oxide becomes positive electrode and the lead negative.

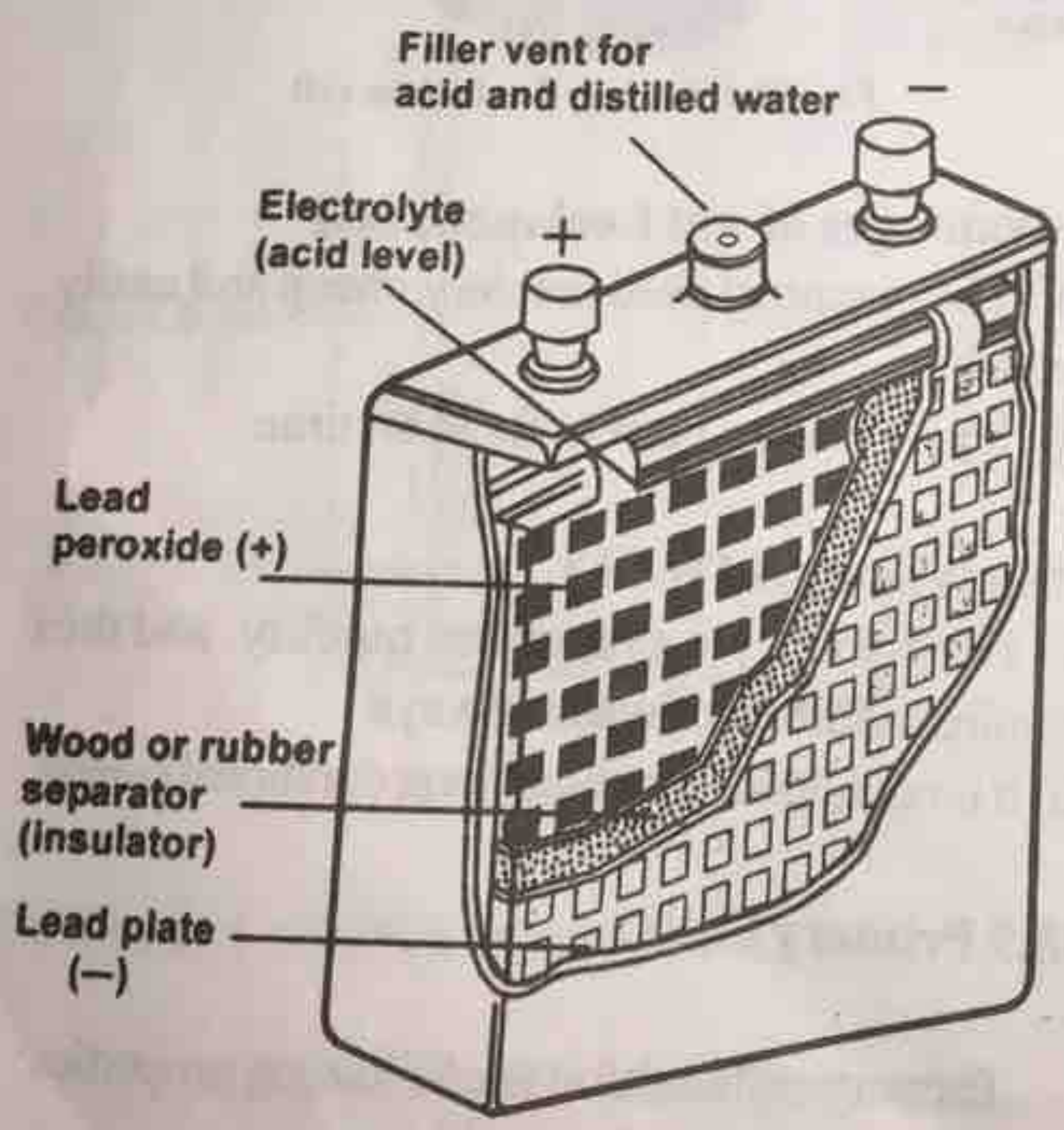

Fig. 38.4 Lead-acid accumulator

Tetraoxosulphate(VI)acid in lead acid evaporates easily. The level should be checked regularly and if necessary distilled water only should be added. It should be charged regularly even when it is not used.

38.12 Differences between Lead-acid Accumulator and Leclanche cell

Lead-acid accumulator	Leclanche cell
(i) It has the capacity to supply large current for a long time.	It has no such capacity.
(ii) It can be re-charged.	It can not be re-charged.

38.13 Alkaline (Nickel-iron Accumulator)

Nickel-iron accumulator was invented by Thomas Edison and Valdemar Jungner in 1900. Cadmium was used as the negative plate, while iron served as the positive plate. The efficiency can be improved by the addition of little iron to cadmium. Alkaline cells have much longer life span than lead cells, although more expensive than lead.

Advantages of alkaline cell

(i) They are suitable for installation for lighting and other purposes.
(ii) Their working process is better than that of lead.
(iii) Alkaline cells have longer life than lead cells.
(iv) No concentration is required about dryness of electrolyte or adding distilled water as a result of evaporation.
(v) It can be recharged.

Disadvantages of alkaline cell

(i) It is expensive compared to lead cells.
(ii) It has low e.m.f value.
(iii) The e.m.f also falls continuously on discharge.