

Energy sources

Thermal energy

1. What is meant by Fuel?

A fuel is defined as naturally occurring or artificially manufactured combustible carbonaceous material which serves as source of heat and light and also in few cases as a source of raw material.

2. Give brief classification of Fuels?

CLASSIFICATION OF FUELS

Fuels are classified into a two types.

- 1) Based on their origin they are classified into:
- a) Primary fuels
 - b) Secondary fuels.

a) Primary Fuels: There are naturally occurring fuels which serves as source of energy without any chemical processing.

Ex: Wood, Coal, Crude oil, Natural gas, Peat, Lignite, Anthracite.

b) Secondary Fuels: - They are derived from primary fuels & serves as source of energy only after subjecting to chemical processing.

Ex: Charcoal, Coke, producer gas, Petrol, Diesel etc.,

- 2) Bases on their physical state fuel are classified into

- a) Solid
- b) Liquid
- c) Gaseous fuels.

	SOLID	LIQUID	GASEOUS
Primary Fuels	Wood, Coal, Peat, Anthracite	Crude oil	Natural gas.
Secondary Fuels	Coke, Charcoal	Petrol, Gasoline, Diesel	LPG, Producer gas, Coal gas.

3. What is meant by calorific value? Mention its units.

Calorific value is defined as the amount of heat liberated when a unit mass of fuel is burnt completely in presence of air or oxygen.

Units: Solid or liquid fuels - K.cal/Kg, Cal/gm.

Gaseous Fuels- Kcal/ m³, B.Th.U/Ft³.

4. Define gross and net calorific value?

- 1) Higher calorific value. (HCV) or Gross calorific value. (GCV)
- 2) Lower calorific value. (LCV) or Net calorific value. (NCV)

1) HCV: - It is the amount of heat liberated when a unit mass of fuels burnt completely in the presence of air or oxygen and the products of combustion are cooled to room temperature. it includes the heat liberated during combustion and the latent heat of steam. Hence its value is always higher than lower calorific value.

2) LCV: - It is amount of heat liberated when a unit mass of fuel is burnt completely in the presence of air or oxygen and the product of combustion are let off completely into air. It does not include the latent heat of steam. Therefore it is always lesser than HCV.

$$\begin{aligned}\text{NCV} &= \text{HCV} - \text{Latent heat of steam.} \\ &= \text{HCV} - 0.09 \times \text{H} \times 587 \text{ cal/g}\end{aligned}$$

5. Explain determination of calorific value of solid or nonvolatile liquid fuel?

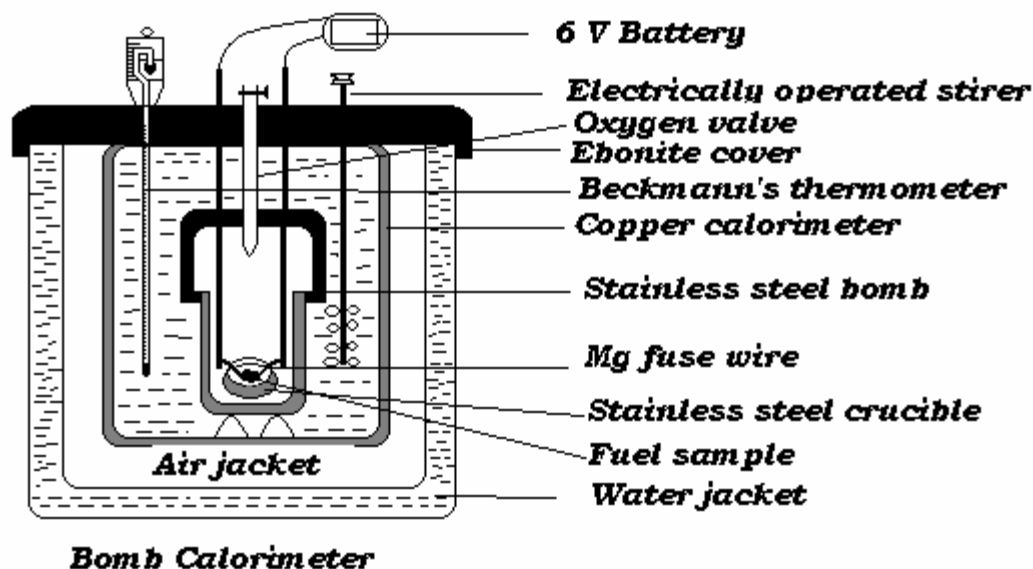
Bomb calorimeter is used to find the calorific value of solid or non volatile liquid fuel.

- **Construction**

- It consists of a strong cylindrical stainless steel bomb in which the combustion of fuel take place.
- The bomb has screwed lid and is provided with stainless steel electrodes and an oxygen inlet valve.
- To one of the electrode a small ring is attached to support crucible.
- The bomb is placed in a copper calorimeter, which is surrounded by an air jacket and water jacket –to prevent heat losses due to radiation.
- The calorimeter is provided with an electrically operated stirrer and Beckmann's thermometer.

Working

- A known mass of the given fuel is taken in a clean crucible which is supported over the ring.
- A fine magnesium wire touching the fuel sample is then stretched across the electrodes.
- The bomb lid is tightly screwed and bomb filled with oxygen to 25 atm pressure.
- The bomb is lowered in copper calorimeter, containing a known mass of water.
- The stirrer is worked and initial temperature(t_1) of the water is noted.
- The electrodes are then connected to 6-volt battery and circuit completed.
- The sample burns and heat is liberated.
- Uniform stirring of water is continued and the maximum temperature attained (t_2) is recorded



Calculation

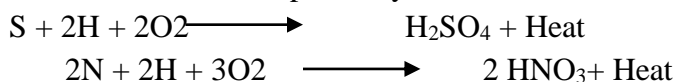
- Let x = mass in g of fuel sample taken in crucible
 - W = mass of water in the calorimeter
 - w = water equivalent in g of calorimeter
 - Stirrer, thermometer, bomb, etc.
 - t_1 = initial temperature of water in calorimeter
 - t_2 = final temperature of water in calorimeter
 - L = higher calorific value in fuel in cal/g.
 - \therefore Heat liberated by burning of fuel = xL
 - And heat absorbed by water and apparatus, etc = $(W + w)(t_2 - t_1)$
- But heat liberated by the fuel = Heat absorbed by water, apparatus, etc,
- $\therefore xL = (W + w)(t_2 - t_1)$

$$\text{or HCV of fuel } (L) = \frac{(W + w)(t_2 - t_1)}{x} \text{ cal/g (or kcal/kg)}$$

Corrections :

To get more accurate results, the following corrections are applied:

- Fuse wire connection** : The heat liberated, as measured above, includes the heat given out by ignition of the fuse wire used.
- Acid correction**: Fuels containing S and N are oxidized, under high pressure and temperature of ignition, to H_2SO_4 and HNO_3 respectively.



Formation of these acids are exothermic reactions. So, the measured heat also includes the heat given out during the acid formation.

iii)Cooling correction: Time taken to cool the water in calorimeter from maximum temperature to room temperature is noted. It is an endothermic reaction and the cooling correction of $dt \times t$ is added to the rise in temperature.

$$L = \frac{(W + w)(t_2 - t_1 + \text{cooling correction}) - [\text{Acid} + \text{fuse corrections}]}{\text{Mass of fuel}(x)}$$

Explain the Analysis of coal by Proximate analysis?

Proximate analysis involves the determinations of moisture, volatile matter, ash and fixed carbon.

(1) **Moisture:** About 1 g of finely powered air-dried coal sample is weighed in a crucible. The crucible is placed inside an electric hot air-oven, maintained at $105^0\text{--}110^0\text{C}$. The crucible is allowed to remain in oven for 1 hour and then taken out, cooled in a desiccator and weighed. Loss in weight is moisture.

$$\text{Percentage of moisture} = \frac{\text{Loss in weight} \times 100}{\text{Wt. of coal taken}}$$

(2) **Volatile matter :** The dried sample of coal left in the crucible in (1) is then covered with a lid and placed in an electric furnace (muffle furnace), maintained at $925^0 \pm 20^0\text{C}$. The crucible is taken out of the oven after 7 minutes of heating. The crucible is cooled first in air, then inside a desiccator and weighed again. Loss in weight is reported as volatile matter on percentage-basis.

$$\text{Percentage of volatile matter} = \frac{\text{Loss in weight due to removal of volatile matter} \times 100}{\text{Wt. of coal sample taken}}$$

(3) **Ash :** The residual coal in the crucible in (2) is then heated without lid in a muffle furnace at $700 \pm 50^0\text{C}$ for $\frac{1}{2}$ hour. The crucible is then taken out, cooled first in air, then in desiccator and weighed. Heating, cooling and weighing is repeated, till a constant weight is obtained. The residue is reported as ash on percentage-basis. Thus,

$$\text{percentage of ash} = \frac{\text{Wt. of ash left} \times 100}{\text{Wt. of coal taken}}$$

(4) **Fixed carbon:**

$$\text{Percentage of fixed carbon} = 100 - \% \text{ of (moisture + volatile matter + ash)}$$

Importance of proximate analysis: Proximate analysis provides following valuable informations in assessing the quality of coal:

1)Moisture in coal evaporates during the burning of coal and it takes some of the liberated heat in the form of latent heat of evaporation. Therefore, moisture lowers the effective calorific value of coal.

2)Volatile matter: A high volatile matter content means that a high proportion of fuel will distill over as gas or vapour, a large proportion of which escapes unburnt, so, higher volatile content in coal is undesirable. A high volatile matter containing coal burns with a long flame,

high smoke and has low calorific value. Hence, lesser the volatile matter, better the rank of the coal.

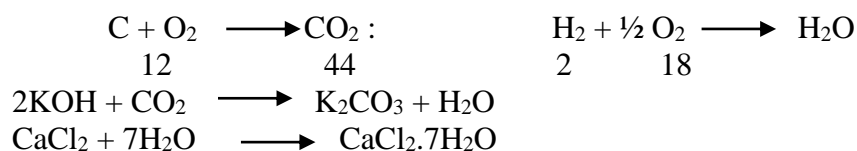
3) Ash is a useless, non-combustible matter, which reduces the calorific value of coal. Moreover, ash causes the hindrance to the flow of air and heat, thereby lowering the temperature. The presence of ash (similar to moisture) also increases transporting, handling and storage costs. It also involves additional cost in ash disposal.

4) Fixed carbon: Higher the percentage of fixed carbon, greater is its calorific and better the quality coal. The percentage of fixed carbon helps in designing the furnace and the shape of the fire-box, because it is the fixed carbon that burns in the solid state.

Explain ultimate analysis of coal.

Ultimate analysis involves the determination of carbon, Hydrogen, nitrogen, sulphur, Ash and oxygen.

1) Carbon and hydrogen: About 1-2 g of accurately weighed coal sample is burnt in a current of oxygen in a combustion apparatus. C and H of the coal are converted into CO₂ and H₂O respectively. The gaseous products of combustion are absorbed respectively in KOH and CaCl₂ tubes of known weights. The increase in weights of these are then determined.



$$\therefore \text{Percentage of C} = \frac{\text{Increase in weight of KOH tube} \times 12 \times 100}{\text{Weight of coal sample taken} \times 44}$$

$$\text{and percentage of H} = \frac{\text{Increase in weight of CaCl}_2 \text{ tube} \times 2 \times 100}{\text{Weight of coal sample taken} \times 18}$$

2) Nitrogen: About 1g of accurately weighed powdered coal is heated with concentrated H₂SO₄ along-with K₂SO₄(catalyst) in a long-necked flask (called Kjeldahl's flask). After the solution becomes clear, it is treated with excess of KOH and the liberated ammonia is distilled over and absorbed in a known volume of standard acid solution. The unused acid is then determined by back titration with standard NaOH solution. From the volume of acid used by ammonia liberated, the percentage of N in coal is calculated as follows:

$$\text{Percentage of N} = \frac{\text{Volume of acid used} \times \text{Normality} \times 1.4}{\text{Weight of coal taken}}$$

3) Sulphur is determined from the washings obtained from the known mass of coal, used in a bomb calorimeter for determination of a calorific value. During this determination, S is converted into sulphate. The washings are treated with barium chloride solution, when barium sulphate is precipitated. This precipitate is filtered, washed and heated to constant weight.

$$\text{Percentage of S} = \frac{\text{Weight of BaSO}_4 \text{ obtained} \times 32 \times 100}{\text{Weight of coal sample taken in bomb} \times 233}$$

4) **Ash** determination is carried out as in proximate analysis.

5) **Oxygen:** It is obtained by difference.

$$\text{Percentage of O} = 100 - \text{Percentage of (C+H+S+N+ash)}$$

Importance of ultimate analysis:

1) **Carbon and hydrogen:** Greater the percentage of carbon and hydrogen, better is the coal in quality and calorific value. However, hydrogen is mostly associated with the volatile matter and hence, it affects the use to which the coal is put.

2) **Nitrogen:** has no calorific value and hence, its presence in coal is undesirable. Thus, a good quality coal should have very little nitrogen content.

3) **Sulphur:** although contributes to the heating value of coal, yet on combustion produces acids (SO_2 and SO_3), which have harmful effects of corroding the equipments. Presence of sulphur is highly undesirable in coal to be used for making coke for iron industry, since it is transferred to the iron metal and badly affects the quality and properties of steel.

4) **Oxygen:** content decreases the calorific value of coal. High oxygen-content coals have high inherent moisture, low calorific value. Oxygen is in combined form with hydrogen in coal so hydrogen available for combustion is lesser than actual one. Thus, a good quality coal should have low percentage of oxygen.

What is meant by carbonization?

Heating of coal in absence of air to remove unwanted impurities like VM, S, P etc; and

Increasing carbon content of the coal or conversion of coal to coke is called carbonization of coal.

This is of two types

1. low temp carbonization
2. high temp carbonization

	low temp carbonization	high temp carbonization
1. Heating temp	500- 700°C	900-1200°C
2. Yield of coke	75 - 80%	65 - 75%
3. % V.M	5 - 15%	1 - 3%
4. Quantity of by products	130 - 150 m ³ /tonne	300 - 390 m ³ /tonne
5. Calorific value	6500 - 9500 Kcal/m ³	5400 - 6000 Kcal/m ³
6. Mechanical strength	Soft	Hard and strong
7. USE	Domestic	Industrial

Explain manufacture of metallurgical coke by Otto Hoffman's by product oven.

To overcome the disadvantages of Beehive oven like 1. to maintain heat economy, 2. to recover valuable by products, 3. to avoid direct heating Otto Hoffmann developed an oven.

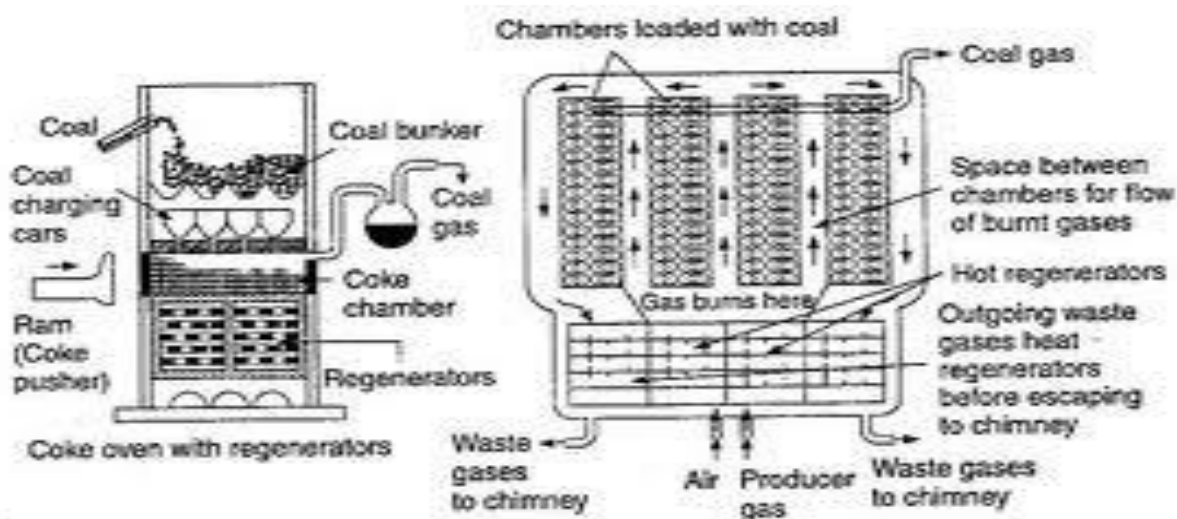
Construction:

- It consists of silicon chambers in which finely divided coal is taken and then closed tightly at both ends. Each chamber is provided with a charging hole at the top, a gas off-take.

- The oven is heated to 1200°C by burning gaseous fuel i.e producer gas and employing a regenerative principle to achieve as economical as possible.
- The flue gases produced during combustion before escaping to chimney, pass on their sensible heat to one of the sets of checker brick work, until this work has been raised to temperature of about 1000°C .
- The flow of heating gases reversed and the inlet gases are passed throw the heated checker work which thus serves to pre heat the inlet gases.
- Thus this cycle goes on.
- The heating is actually continued till the evolution of volatile matter ceases completely.
- Carbonization of charge of coal takes about 11 - 18 hours.

RECOVERY OF BY PRODUCTS

- The gas coming out of oven is known as coke oven gas mainly composed of ammonia, H₂S, naphthalene, benzene, tar, etc.
 1. recovery of tar: the coke oven gas passed through a tower where liquid ammonia is sprayed, Tar absorbed by ammonia, collected in a tank below.
 2. Recovery of Ammonia: the gases from above chamber passed throw a tower in which water is sprayed, then ammonia is collected into a water as NH₄OH.
 3. recovery of Naphthalene: The gases are then passed through another tower in which cool water is sprayed , here naphthalene get condensed.
 4. Recovery of benzene: The gases are then sprayed with petroleum, when benzene and its homologous are collected.
 5. Recovery of H₂S: The gases are then passed through purifier packed with Fe₂O₃, here H₂S is retained



CHEMICAL ENERGY FUEL

1. What is meant by electrochemical cell and electrolytic cell?

- A cell is a device which convert **chemical** energy in to **electrical** energy is called **electrochemical cell**.
- A cell is a device which convert **electrical** energy in to **chemical** energy is called **electrolytic cell**.
- **Electrochemical cell** consists of two electrodes immersed in a electrolyte and connected externally with a metal wire.
- **Electrode** is a set up in which the metal is immersed in its salt solution.
- **Anode:** It is a **-ve** electrode where the electrons leave from it, or the electrode where oxidation takes place.
- **Cathode:** It is a **+ve** electrode where the electrons Enter through it, or the electrode where reduction takes place.

2. Define standard electrode potential.

standard electrode potential is the measure of tendency of metallic electrode to lose or gain electrons, when it is in contact with its own salt of unit concentration at 25°C.

- The measure of tendency an electrode to lose electrons is called Oxidation potential.
- The measure of tendency an electrode to gain electrons is called Reduction potential.
- The reduction potential and Oxidation potential in magnitude same but differ in sign i.e; if the oxidation potential of an electrode is +X Volts, then the reduction will have the value of -X Volts.

3. What is electrochemical series? Give its significance.

When all the elements are arranged in increasing order of their standard reduction potential that series is called electro chemical series.



-3.05	-1.66,	-0.76	0.00	0.34	0.80	+2.87
anode			Reference			Cathode

Significance:

- **Relative ease of Oxidation or reduction:** A system with high reduction potential has a great tendency to undergo reduction, and with low reduction potential has tendency to undergo oxidation. Top most elements in the series act as reductants and bottom elements act as Oxidants.
- **Replacement tendency:** Higher value of reduction potential element shows tendency to be in reduced form. Hence in a reaction zinc sulfate solution added to copper, Cu does not change and stay in the reduced state, but in a reaction zinc added to copper sulfate, zinc replaces Cu and gives zinc sulfate & copper. Here Cu is reduced due high reduction potential.
- **Predicting spontaneity of redox reactions:**

E.M.F of cell = E cathode - E anode

is positive, reaction is spontaneous
is negative, reaction is non spontaneous

➤ **Calculation of Equilibrium constant**

By the equation $E = \frac{RT \log K_c}{nF}$ = Equilibrium constant

if E electrode potential is known K_c can be determined by above equation

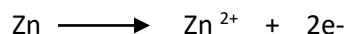
4. Define battery? Explain construction and working of dry or Laclanche cell with neat sketch.

- Battery is defined as it is an electrochemical cell or several electrochemical cells in series that can be used as a source of direct electrical current at a constant voltage.
- Dry or Laclanche cell:
- It is a primary cell or pure electrochemical cell which consists of only Discharging cycle can convert chemical energy to electrical energy.
- Anode: Zn can
- Cathode: Graphite surrounded by MnO_2 .
- Electrolyte: $\text{ZnCl}_2 + \text{NH}_4\text{Cl} + \text{Starch}$

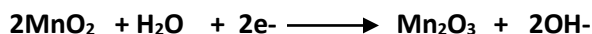
Construction:

It consists of graphite rod at the centre surrounded by a paste consists of MnO_2 , NH_4Cl and ZnCl_2 made with starch. this entire assembly is placed inside a thin Zinc can

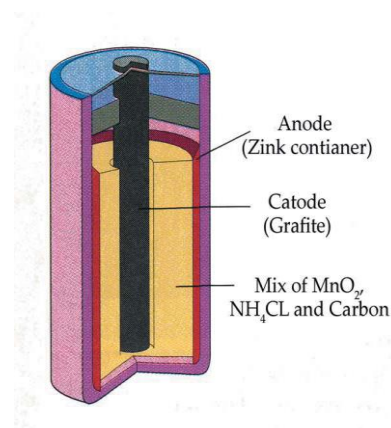
Reactions at Anode:



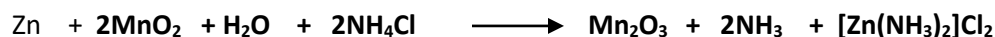
Reactions at Cathode:



Secondary reactions:



Net reaction:



EMF of the cell: 1.5V

Disadvantages:

- When electricity is drawn quickly the products of secondary reactions will build up, so there is sudden drop in potential observed.
- Even though cell is not in use due to acidic electrolyte cell will discharge continuously.

5. Explain alkaline battery.

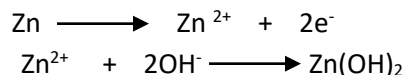
ALKALINE BATTERY:

- Anode: Zn can
- Cathode: Graphite surrounded by MnO₂.
- Electrolyte: KOH + Zn powder

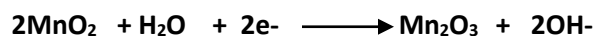
Construction:

It consists of graphite rod at the centre surrounded by a paste consists of MnO₂, the electrolyte KOH is mixed with Zn powder, this entire assembly is placed inside a thin Zinc can

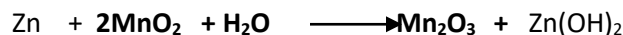
Reactions at Anode:



Reactions at Cathode:



Net reaction:



EMF of the cell: 1.5V

6. What are storage devices? Explain the construction and working of a lead acid accumulator.

A. Storage device:

Lead acid accumulator:

- It is a secondary cell which consists of both Discharging and recharging component can convert chemical energy to electrical energy by acting as an electrochemical cell and convert electrical energy into chemical energy by acting as an electrolytic cell.
- Anode: spongy lead
- Cathode: PbO₂ coated lead.
- Electrolyte: 20% H₂SO₄

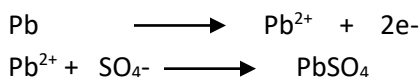
Construction:

It consists of lead as anode and PbO₂ coated lead as a cathode immersed in a 20% H₂SO₄ electrolyte either a single pair or series of pairs immersed in an electrolyte with porous partition between the pairs.

While discharging :

It acts as an electrochemical cell and converts chemical energy into electrical energy

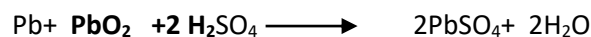
Reactions at Anode:



Reactions at Cathode:



Net reaction:



EMF of the cell: 1.8 - 2.2V

While charging:

it acts as electrolytic cell which convert electrical energy into chemical energy.

Reactions at '-' terminal:



Reactions at '+' terminal:



Net reaction:



- In discharging process the electrolyte component acid is converted into equivalent of water and in charging process the water is converted to equivalents of acid, thus at any time the concentration or specific gravity of acid will determine the life a battery.

7. Explain working of H_2 - O_2 Fuel Cell

A cell which converts chemical energy of a fuel directly into electrical energy is called fuel cell

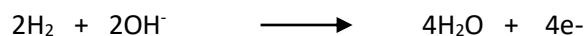
Fuel + Oxygen \longrightarrow Oxidation products + Electrical energy

- Anode: H_2 the Fuel
- Cathode: **O_2 The oxidant**
- Electrolyte: 25%KOH
- Electrodes are made of graphite impregnated with finely divided Pt, Pd, Ag, Or Ni

Construction:

It consists of Porous graphite Cylinders impregnated with finely divided Pt, Pd, Ag, Or Ni , in one electrode fuel H_2 Is pumped at 50 atm and in the other electrode O_2 is pumped.the electrolyte is KOH

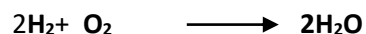
Reactions at Anode:



Reactions at Cathode:



Net reaction:



EMF of the cell: 1.2V

- **Electrolyte generally used are aqueous KOH or H_2SO_4 or ion exchange resin saturated with water.**

Give the Applications of Hydrogen - oxygen fuel cell?

- **Used as auxiliary energy source in space vehicles, submarines and other military vehicles.**
- **The product water is a valuable source of fresh water by astronauts.**
- **Widely used as a source of power in transportation like electric mobiles etc.**
- **Efficiently employed for power generation which is used for domestic and industrial purpose.**

Other general questions:

Distinguish between electrolytic and electrochemical cell.

Distinguish between primary and secondary cells.

Explain Galvanic cell.

Explain the role of salt bridge.

What is the significance of electrode potential?

Write a brief note on electrode potential.

Li-ion battery

Many of the commercial batteries are not able to meet the performance of many applications. Batteries with high energy level, long life, low cost, little or no maintenance and safety are required.

Lithium is theoretically an active material for negative electrode of electrochemical cell (due to its least noble nature, low specific gravity)

Lithium-ion batteries are incredibly popular and are found in [laptops](#), [PDAs](#), [cell phones](#) and [iPods](#) as they are most energetic rechargeable batteries.

Lithium ion battery:

A lithium-ion battery or Li-ion battery is a [rechargeable battery](#).

[Like any other battery, a rechargeable lithium-ion battery is made of one or more power-generating compartments called **cells**. Each cell has essentially three components: a **positive electrode** (connected to the battery's positive or + terminal), a **negative electrode** (connected to the negative or – terminal), and a chemical called an **electrolyte** in between them. The positive electrode is typically made from a chemical compound called lithium-cobalt oxide (LiCoO_2) or, in newer batteries, from lithium iron phosphate (LiFePO_4). The negative electrode is generally made from carbon (graphite) and the electrolyte varies from one type of battery to another.]

Metal case holds a long spiral comprising three thin sheets pressed together:

- A **Positive electrode**
- A **Negative electrode**
- A **separator**

Inside the case these sheets are submerged in an organic solvent that acts as the electrolyte. Ether is one common solvent.

The separator is a very thin sheet of microperforated plastic, it separates the positive and negative electrodes while allowing ions to pass through.

Negative electrode (Anode): Lithiated carbon (used instead of Lithium)

Positive electrode (Cathode): Lithiated transition metal intercalation compound. (LiCoO_2 , LiMnO_2)

Electrolyte: mixture of organic carbonates. (Li salt in organic solvent-ethylene/diethyl carbonate with Li ions)

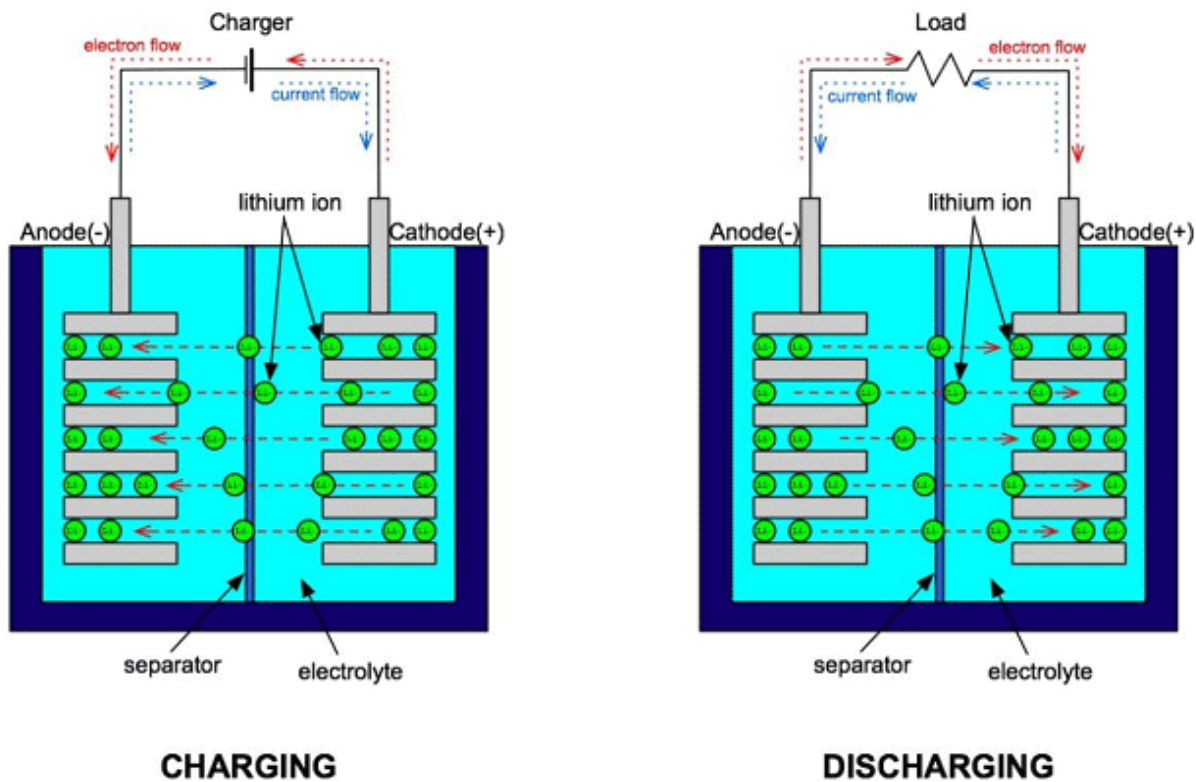
[Non aqueous electrolyte is used as Li is highly reactive with water and forms its hydroxide and H_2]

During discharge: lithium ions move from the negative electrode to the positive electrode

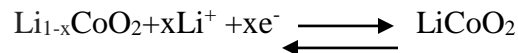
While charging: lithium ions move from the positive electrode to the negative electrode

[Both the electrodes allow Li^+ to move in and out of their interiors. no chemical change occurs in the two electrodes or in the electrolyte. During insertion (intercalation)- ions move into the electrode. During extraction (deintercalation) - ions move back out]

The movement of these lithium ions happens at a fairly high voltage, so each cell produces 3.7 volts.



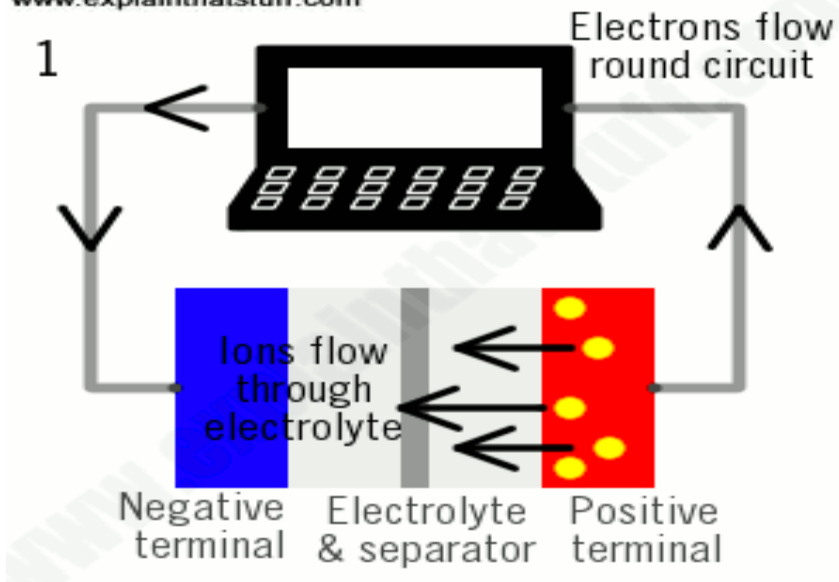
The cathode (marked +) half-reaction is



The anode (marked -) half reaction is:



In a lithium-ion battery the lithium ions are transported to and from the positive or negative electrodes by oxidizing the transition metal, cobalt (Co), in $\text{Li}_{1-x}\text{CoO}_2$ from Co^{3+} to Co^{4+} during charge, and reduced from Co^{4+} to Co^{3+} during discharge.

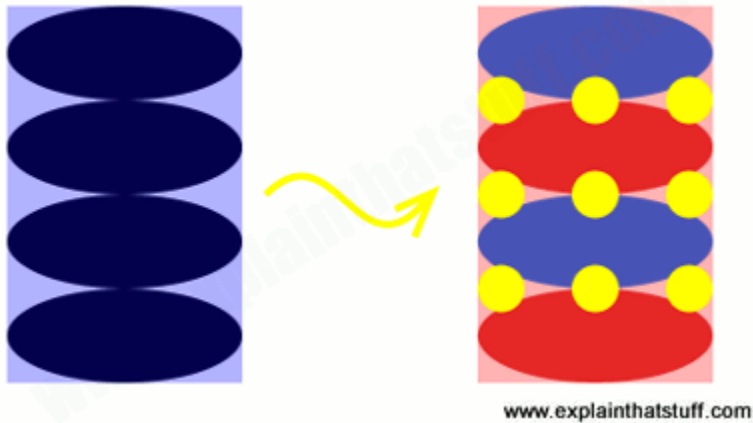


1. During charging, lithium ions (yellow circles) flow from the positive electrode (red) to the negative electrode (blue) through the electrolyte (gray). Electrons also flow from the positive electrode to the negative electrode, but take the longer path around the outer circuit. The electrons and ions combine at the negative electrode and deposit lithium there.
2. When no more ions will flow, the battery is fully charged and ready to use.
3. 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 your laptop. When the ions and electrons combine at the positive electrode, lithium is deposited there.
4. When all the ions have moved back, the battery is fully discharged and needs charging up again.

How are the lithium ions stored?

This second animation shows what's going on in the battery in a bit more detail. Again, the negative graphite electrode (blue) is shown on the left, the positive cobalt-oxide electrode (red) on the right, and the lithium ions are represented by yellow circles. When the battery is fully charged, all the lithium ions are stored between layers of [graphene](#) (sheets of carbon one atom thick) in the graphite electrode (they have all moved over to the left). In this charged-up state, the battery is effectively a multi-layer sandwich: graphene layers alternate with lithium ion layers. As the battery discharges, the ions migrate from the graphite electrode to the cobalt-oxide electrode (from left to right). When it's fully discharged, all the lithium ions have moved over to the cobalt-oxide electrode on the right. Once again, the lithium ions sit in layers, in between

layers of cobalt ions (red) and oxide ions (blue). As the battery charges and discharges, the lithium ions shunt back and forth from one electrode to the other.



Advantages:

- Higher energy density, higher cell voltage(2.9 V to 4.2 V)
- Much lighter than other types of rechargeable batteries of the same size
- Electrodes of a lithium-ion battery are made of lightweight **lithium** and **carbon**
- Lithium-ion batteries can handle hundreds of charge/discharge cycles.
- Simple to charge and maintain

Disadvantages:

- They start degrading as soon as they leave the factory. They will only last two or three years from the date of manufacture whether you use them or not.
- They are extremely sensitive to high temperatures. Heat causes lithium-ion battery packs to degrade much faster than they normally would.
- If a lithium-ion battery is completely discharged, it gets ruined.
- More expensive.
- There is a small chance that, if a lithium-ion battery pack fails, it will burst into flame.

