1. How fuels are classified. Give one example for each.

Based on Occurrence - 2 Types.

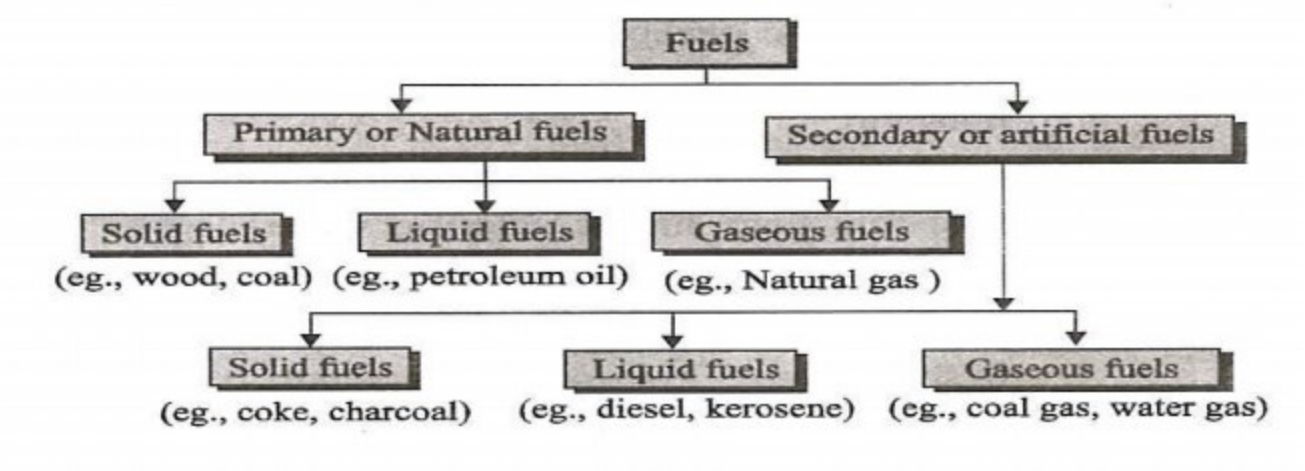
Primary Fuels – It occurs in nature such as. Ex: Coal, Crude oil, Natural Gas.

Secondary Fuels – It is derived from primary fuels. Ex: Coke, Petrol, Coal gas. Based on physical state – 3 types

Solid fuels, eg., coal, coke,

Liquid fuels eg., gasoline, diesel.

Gaseous fuels eg., coal gas, natural gas.



2. Define calorific value. Explain higher & lower calorific value.

It is defined as the amount of heat obtainable by the complete combustion of a unit mass of the fuel. Units of Calorific value ; Calorie, kilocalorie, British thermal unit, centigrade heat unit Higher calorific value / Gross calorific value (GCV)

GCV = The total amount of heat is produced, when a unit quantity of the fuel is completely burnt and the products of combustion are cooled to room temperature is known as GCV.

Lower calorific value / Net calorific value (GCV)

NCV = The total amount of heat is produced, when a unit quantity of the fuel is completely burnt and products of combustion are allowed to escape is known as NCV

NCV = GCV -0.09H x 587.

3. Explain proximate analysis. Give its significance.

It involves the determination of % of moisture content, volatile matter, ash content & fixed carbon in coal.

(i) Moisture content: About 1 gram of air-dried powdered coal sample is taken in a crucible & it is heated at 100-105°C for 1 hour.

$$\%\text{ of moisture in coal} = \frac{\text{loss in weight of the coal}}{\text{weight of Air-dried coal}} \times 100$$

(ii) Volatile matter: After the analysis of moisture content, the crucible with residual coal sample is converted with lid & it is heated upto 950°C for 7 minutes.

$$\%\text{ of Volatile mater in coal} = \frac{\text{loss in weight of the coal}}{\text{weight of moisture-free coal}} \times 100$$

(iv) Fixed carbon: It is determined by the subtracting the sum total of moisture, volatile & ash content from 100.

% of fixed carbon in coal = 100 - % of (moisture content + volatile matter + ash content)

Significance or importance of Proximate Analysis:

High % of moisture is undesirable because it reduces the calorific value of a fuel, & increases the transport cost.

High % of matter is undesirable because it reduces the calorific value of a fuel & coal burns with a long flame & high smoke.

High % of ash content is undesirable because it reduces the calorific value of a fuel & makes the additional cost of disposal of ash.

High % of fixed carbon in a coal, is greater its calorific value.

4. Explain ultimate analysis. Give its significance.

It involves the determination of % of Carbon, Hydrogen, Nitrogen, Sulphur & Oxygen in coal.

1. Carbon & Hydrogen: A known aount of coal sample is burnt with o2 in a combustion apparatus. In coal carbon & hydrogen are converted into CO_2 & H_2O & those are absorbed by KOH tubes & $CaCl_2$ tubes.

$C + O_2 \longrightarrow CO_2$

12 44

$$\% \text{ of Carbon in coal} = \frac{\text{Increase weight in KOHtubes}}{\text{Weight of coal sample taken}} \times \frac{12}{44} \times 100$$

$H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$

2 18

$$\% \text{ of Hydrogen in coal} = \frac{\text{Increase weight in } CaCl_2 \text{ tubes}}{\text{Weight of coal sample taken}} \times \frac{2}{18} \times 100$$

2. Nitrogen:

It is carried out by Kjeldahl‟s method. A known amount of coal is heated with Con. H_2SO_4 in presence of K_2SO_4 catalyst in a long necked flask called Kjeldahl‟s flask. Nitrogen is converted into ammonium sulphate. Then it is heated with NaOH & absorbed by HCl.

$$\% \text{ of Nitrogen in coal} = 1.4 \times \frac{\text{volume of acid consumed}}{\text{Weight of coal sample}}$$

3. Sulphur: A known amount of coal is completely burnt in a bomb calorimeter. Here sulphur is converted into sulphate & treated with $BaCl_2$, $BaSO_4$ is obtained.

Oxygen: The % of oxygen is calculated as follows,

of Oxygen in Coal = 100 - % of (C + H+N+S+ash)

Importance or significance of Ultimate analysis:

Higher % of carbon & hydrogen, better is the quality of coal & higher its calorific value.

Should have very little nitrogen content.

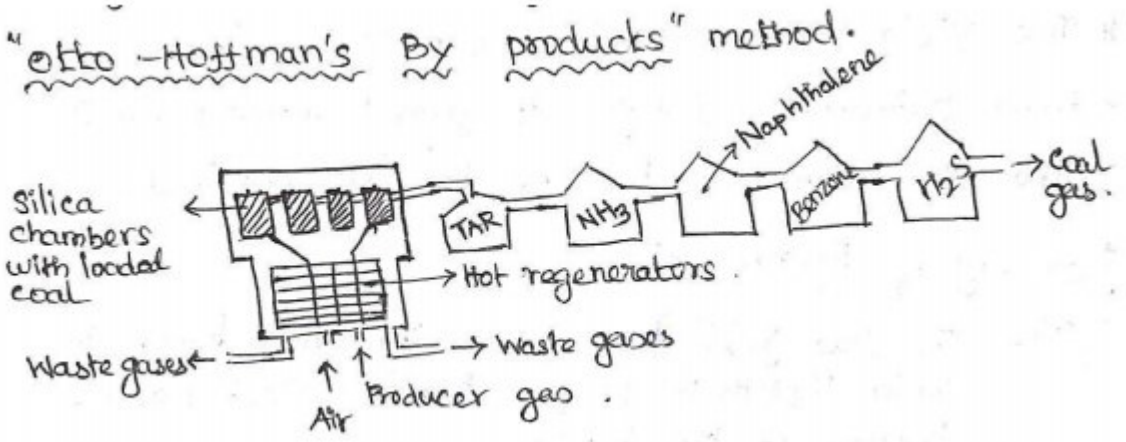
Presence of sulphur is undesirable because it forms harmful gases during the combustion.

Lower of the Oxygen increases the higher its calorific value.

How Metallurgical coke is manufactured by Otto-Hoffman's method?

When bituminous coal is heated strongly in the absence of air, the volatile matter escapes out & the mass becomes hard, strong, porous, which is called **metallurgical coke.**

Manufacture of Metallurgical coke by "Otto- Hoffman's by products" method:



In order to (i) Increase the thermal efficiency of the carbonization process & (ii) Recover the valuable by products by this method.

This oven consists of a number of silica chambers.

Each chamber is about 10-12 m long, 3-4 m height & 0.4 – 0.45m wide.

Coal is introduced into the silica chambers & heated 1200°C by air & producer gas. I & IV regenerators are heated by hot flue gases & II & III regenerators are

heated by incoming air & producergas.

When the process is complete, the coke is removed & cool by with water. Time taken for this process is 12-20 hours.

The yield of the coke is about 70%

From out coming flue gas, it gives valuable products like Tar, ammonia, benzene. H_2S are obtained.

Recovery of by products:

(i) Tar: the flue gases are first passed through a tower, in which liq. NH_3 is sprayed, tar is collected at the bottom of the tank.

(ii) Ammonia: The gases are then passed through 2nd tower, in which water is sprayed & NH_3 gets in the form of NH_4OH.

(iii) Naphthalene: The gases are again passed through next tower, cooled water is sprayed, Naphthalene gets & condensed.

(iv) Benzene: The gases are passed through next tower, petroleum oil is sprayed, benzene gets condensed.

(v) H2S gas: The remaining gases are then passed through a purifier, H_2S gas is obtained. The final gas left out is called coal gas.

Advantages:

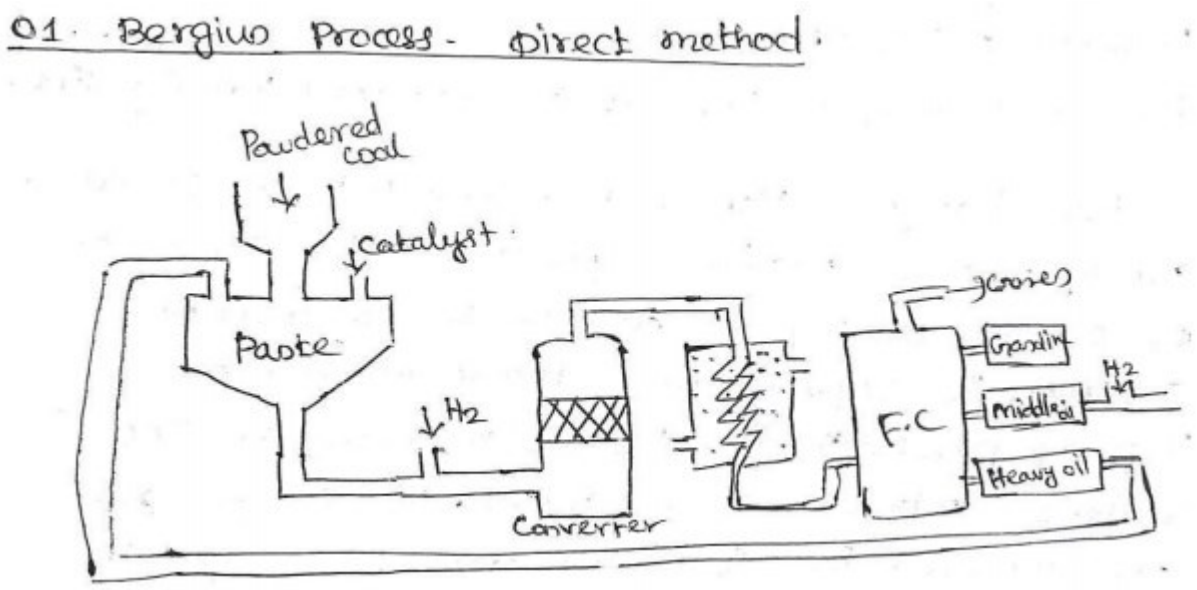
(i) Valuable by product like NH_3, benzene, etc are obtained.

The carbonization time is less.(iii) Heating is done by extremely by producer gas.

What do you mean by hydrogenation of coal? How Synthetic petrol is manufactured by Bergius Process? Or How solid fuel is converted into liquid fuel? Explain in detail.

The preparation of liquid fuels from solid coal is known as hydrogenation of coal & this gasoline is known as synthetic petrol.

Bergius Process – Direct method:



Input : Powdered coal + Ni Oleate catalyst + Heavy oil are made into paste + H_2

Heating in : 400 - 450°C.

Pressure : 200-250atm.

Process: Powdered coal is converted into gasoline.

In this process powdered coal is mixed with Ni oleate & heavy oil & made into paste.

It is pumped along with H2 gas into the converter, the paste is heated to 400 - 450°C under pressure of 200-250atm.

Crude oil comes & it is fractionated into 3 parts.

1. Gasoline. 2. Middle oil. 3. Heavy oil.

The middle oil is further hydrogenated in vapour phase to get gasoline. The heavy oil is recycled for making paste again coal powder.

60% of yield is obtained from this process.

7. Explain the following (i) Compressed natural gas (CNG) (ii) Liquid petroleum gas. (LPG)

Compressed Natural Gas: (CNG)

Natural gas (CH_4) compressed to a pressure of about 1000 atm is known as CNG. Its calorific value is 12000-14000kcal/m^3.

It is fully of methane only & derived from natural gas. Its composition is as follows.

CH_4 = 70-90% C_2 H_2 = 5- 10 % H_2 = 3%

Uses: CNG is a cheapest, clearest & the least polluting fuel for automobiles instead of petrol or diesel.

(ii) Liquid Petroleum Gas: (LPG)

It is obtained as a by- product during the cracking of heavy oil. Its composition is

Butane = 27% Isobut ene = 25% Butyle nes = 43% Propan e = 5%

Its calorific value is 27,800 kcal /m^3.

LPG is marketed under the trade names like Indane, HP, Bharat gas in steel cylinders under high pressure.

A small amount of Ethyl mercaptan is added during filling of cylinders to help in detecting leakage of gas.

LPG ensures complete combustion with no smoke & causes the least environmental pollution.

Uses:

It is used as a domestic fuel.

It is used as a fuel in vehicles (i.e) motor fuel.

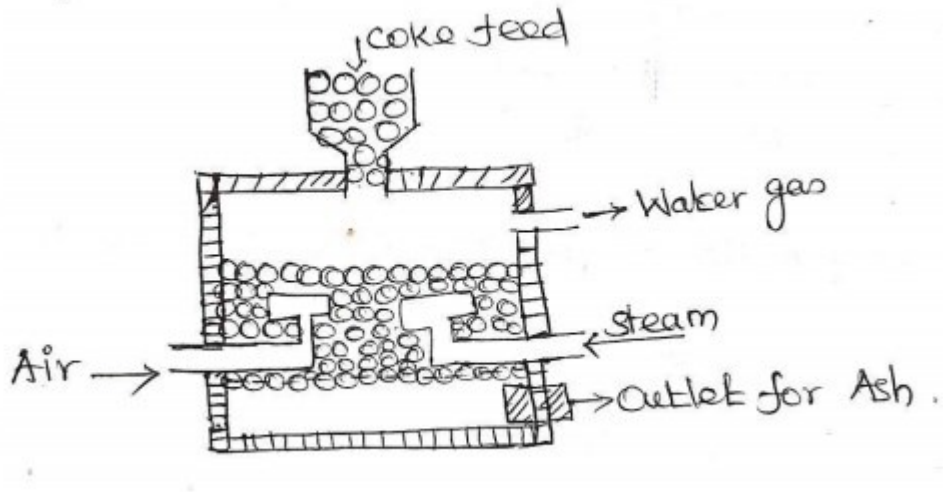
It is used in industries & laboratories

Explain Water gas with reaction.

It is a mixture of CO & H_2 with small amount of N_2.

Its calorific value is about 2800kcal/m^3.

Composition: CO = 41%, H_2 = 51%, N_2 = 4% & CO_2 = 4%.



The water gas producer consists of a tall steel vessel, lined with refractory bricks.

It is provided with cup & cone feeder at the top & side opening for water gas exists. At the bottom it is provided with 2 inlet pipes for passing air & steam.

When steam & little air is passed alternatively over a red hot coke maintained at about 900-1000°C in a reactor, water gas is produced.

Two steps of reaction in production of water gas:

Step 1: $\underset{\text{Coke}}{C} + \underset{\text{steam}}{H_2O} \longrightarrow \underset{\text{water gas}}{CO + H_2}$. ENDOTHERMIC

Here the steam is passed through red hot coke, where CO & H2 gases are produced. The reaction is endothermic.

Step 2: $C + O_2$ --- > CO_2. EXOTHERMIC.

Uses:

It is used for preparation of power alcohol.

For the production of H_2 & in synthesis of NH_3.

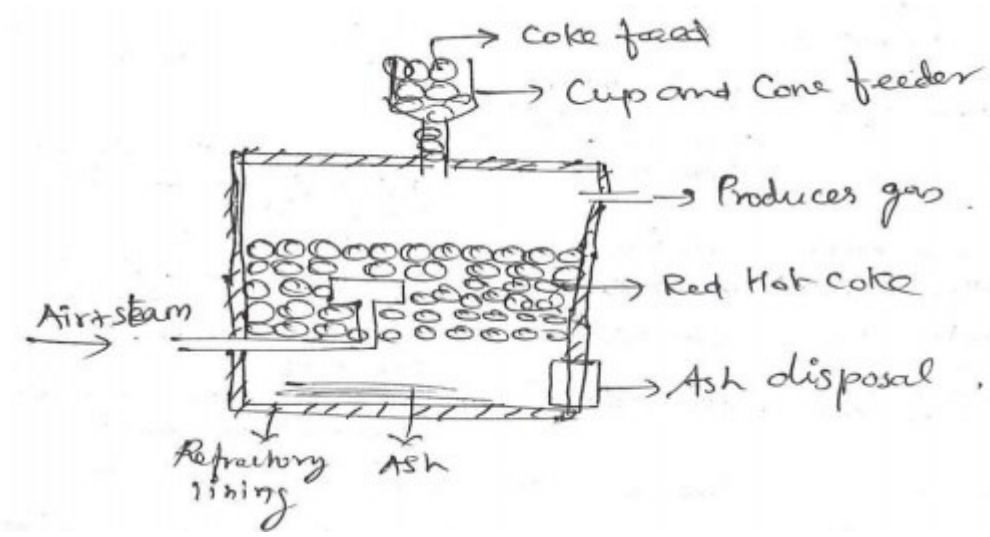
To manufacture synthesis petrol in Fischer – Tropsh process.

Explain Producer gas with reaction.

It is a mixture of CO & N_2 with small amount of

H_2. Its calorific value is about 1300 kcal/m^3.

Composition: CO = 30%, H_2 = 10-15%, N_2 = 51-56% & others = rest.



The producer gas producer consists of a tall steel vessel, lined inside with refractory bricks. It is provided with cup & cone feeder at the top & side opening for producer gas exit.

At the bottom it is provided with an one inlet for passing air & steam.

When a mixture of air & steam is passed over a red hot coke at 1100°C in a reactor, the producer gas is produced.

$$\underset{\text{Coke}}{C} + \underset{\text{from air}}{O_2 + N_2} \longrightarrow \underset{\text{producer gas}}{CO + N_2}.$$

Uses:

It is a used as a reducing agent in metallurgical operations.

Used for heating muffle furnaces & open- hearth furnaces.

Describe flue gas analysis by Orsat's apparatus method.

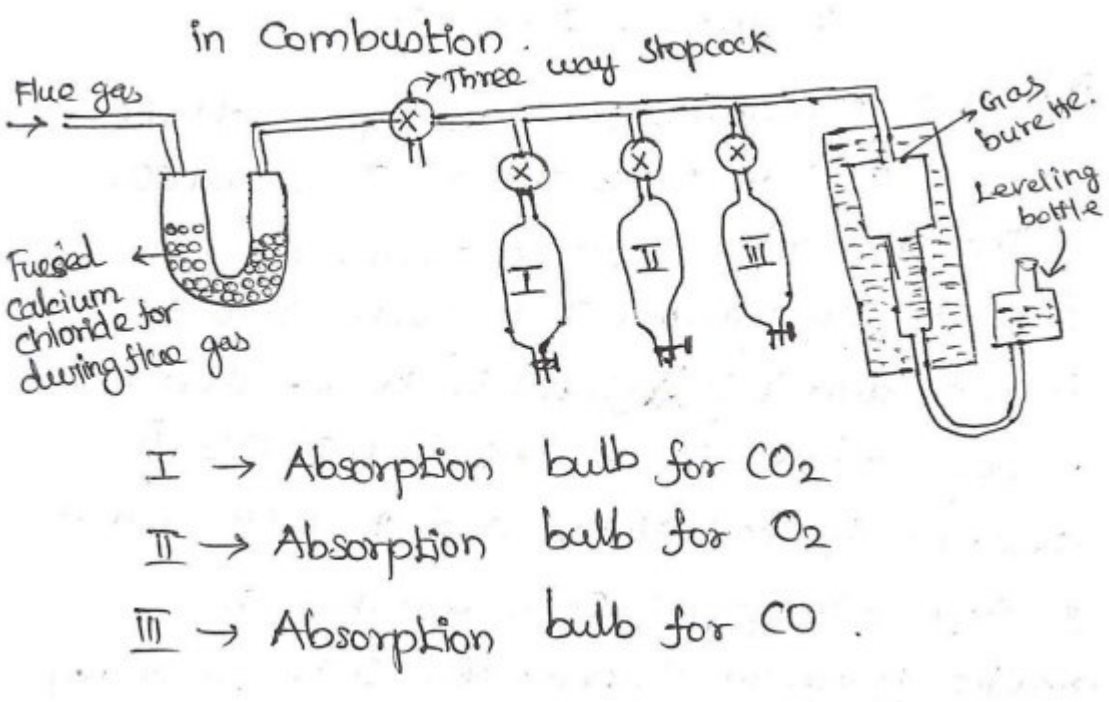
Flue gas analysis is carried out by Orsat apparatus method.

A mixture of gases like CO_2, CO, O_2 & N_2 etc coming out from the combustion chamber is called flue gases.

If the flue gas contains,

CO -- It indicates incomplete combustion &

O_2 -- It indicates excess supply of air used in combustion.



Apparatus: It consists a horizontal tube. At one end this tube, U tube containing fused $CaCl_2$ is connected through 3 way stop cock. The other end is connected with a graduated burette. The horizontal tube is also connected with 3 different absorption bulbs I, II, III for absorbing CO_2, CO and O_2.

I bulb: It contains KOH solutions & it absorbs CO_2 only.

II bulb: It contains Alkaline pyrogallol solution & it absorbs CO_2, & O_2

III bulb: It contains Ammoniacal cuprous chloride solution & it absorbs CO_2,CO & O_2

The 3 way stop cock is connected with flue gas supply & it is sucked into the burette & it is adjusted by 100cc. then the 3 way stop cock is closed. In bulb I, co_2 is absorbed by KOH solution & I is closed & II stopcock is opened, O_2 is absorbed by alkaline pyrogallol solution. Now II is closed & III is opened. CO is absorbed by ammonical cuprous chloride. The decrease in volume of the flue gas in the burette indicates the volume of I CO_2, II O_2,

III CO respectively.

Significance: It gives an clear idea about the complete or incomplete process.