

FUELS

(PART - II)

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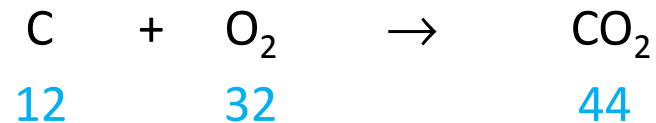
Sem V General (DSE-1A)

Summary of Fuel (Part – I)

- Definition of fuel
- Classification of fuel
- Calorific value
- GCV and NCV
- Characteristics of a good fuel
- Coal – origin – carbonisation of coal – LTC, HTC

Q1. Calculate the weight and volume of air required for the complete combustion of 10kg of carbon.

Complete combustion of carbon can be represented as :



Wt. of oxygen required for combustion of 12 g of C = 32g

Wt. of oxygen required for 10 kg of carbon = $(32/12) \times 10 = 26.67$ kg

Wt. of air (containing 23% oxygen) required = $(100/23) \times 26.67 = 116$ kg

At NTP 32 g oxygen occupies 22.4 L

At NTP 26.67 kg oxygen will occupy $(22.4/32) \times 26.67 \times 1000 = 18669$ L

Vol. of air (containing 21% oxygen) required = $(100/21) \times 18669 = 88900$ L

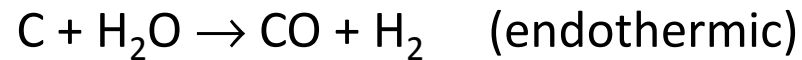
SECONDARY GASEOUS FUEL

Water gas:

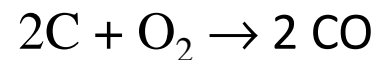
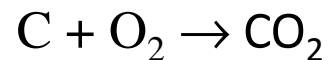
- It is a mixture of CO and H₂ (combustible) and small amount of non combustible gases like CO₂ and N₂.
- CO (41%), H₂ (51%), N₂ (4%), CO₂ (4%)
- Calorific value is 2800 Kcal/m³
- Uses:
 1. source of hydrogen
 2. fuel
 3. raw material for synthetic petrol

Preparation:

It is prepared by passing steam over red-hot bed of coke or coal at about 900-1000 °C.



As the process is endothermic, so the temperature of the bed falls. At this juncture, the supply of steam is stopped temporarily to raise the temperature of the bed to 900-1000 °C. Air is blown, the oxygen of air reacts with carbon to form CO₂ and CO which are exothermic processes and bed temperature rises. These two steps are therefore repeated alternatively.



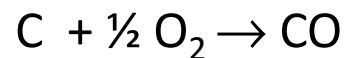
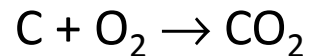
Producer gas:

- It is a mixture of CO (combustible gas) and N₂ (non-combustible gas).
- CO (20 – 30 %), N₂ (50 – 55%), H₂ (8 – 12%), CO₂ (2 – 3%)
- Calorific value is 900 - 1300 Kcal/m³
- Uses:
 1. reducing agent in metallurgical processes
 2. fuel for open hearth furnaces, muffle furnace, coke oven plants etc.

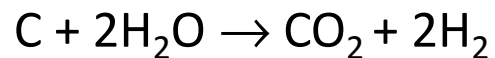
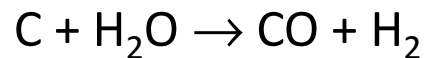
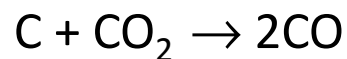
Preparation:

It is prepared by passing air mixed with small volume of steam over red hot coal or coke at 1100 °C in specially designed reactor called 'gas producer'. It is a two step process.

(i) *Oxidation*: Here, the carbon of coke or coal gets oxidized in the presence of air.



(ii) *Reduction*: In this case, CO₂ and steam react with carbons of coke or coal and liberate hydrogen and CO.



The reduction process is endothermic. Such reactions are allowed to take place deliberately. The temperature cannot rise to more than 1000 °C, to affect refractory lining and fusing ash so produced.

Coal gas:

- Main constituent of coal gas is H_2 and CH_4 .
- H_2 (40%), CH_4 (32%), CO (7%), C_2H_2 (25%) and others.
- Calorific value is 4900 Kcal/m^3
- Uses:
 1. an illuminating gas for lighting
 2. as a gaseous fuel
 3. for reducing atmosphere in metallurgical industries

Preparation:

It is prepared by the carbonisation (heated in absence of air) of coal at about 1300 °C. Generally coal is taken in closed silica retorts and heated to 1300 °C by burning a mixture of producer gas and air in separate enclosures adjoining silica retorts.

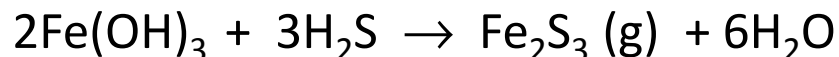


The coal gas so produced is impure, and through several processes the impurities are removed and coal gas is purified.

Tar and ammonia are removed by cooling the gas and water scrubbing.

Benzol, naphthalene are removed by creosote oil scrubbing.

H₂S is finally removed by passing the gas over ferric hydroxide.



PETROLEUM (LIQUID FUEL)

- Petra = rock, oleum = oil
- Petroleum is a viscous oil found deep in the earth's crust.
- Its is often called 'rock oil'.
- Crude petroleum is a mixture of various hydrocarbons with small quantities of organic compound containing oxygen, nitrogen and sulphur. Most of the hydrocarbons are straight chain paraffins and aromatic hydrocarbons, such as benzene, toluene, naphthalene etc. Olefins and acetylenes are absent in crude oil, but are formed during the processing of petroleum. Oxygen is present as ketones, phenols and carboxylic acids. Nitrogen is present as pyridine, pyrrole, quinoline derivatives etc. Sulphur is present as alkyl sulphides, aromatic sulphides, H₂S and elemental sulphur.
- Elemental composition: C (80 - 87%), H (11 – 15%), S (0.1 – 3.5 %), O (0.1 – 1%), N (0.3 – 1%).

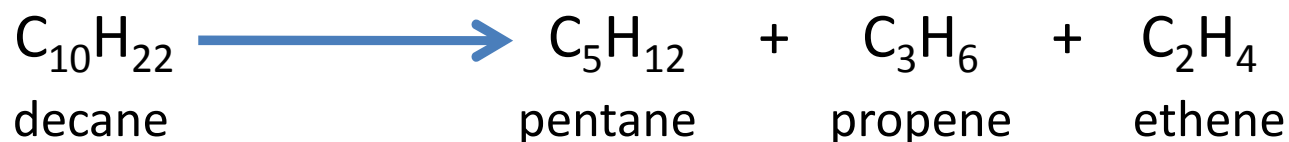
Refining of petroleum

- 1. Separation of water (Cottrell's Process):** The crude oil from the oil well is an extremely stable emulsion of oil and salt water. It is separated from water by allowing the crude to flow between two highly charged electrodes. The colloidal water droplets coalesce to form bigger drops and separate from the oil.
- 2. Removal of sulphur:** The oil is treated with copper oxide when sulphur gets converted into insoluble copper sulphide which can be removed by filtration.
- 3. Fractional distillation:** The crude oil is then heated to about 400 °C in an iron retort, whereby all constituents except the residue are evaporated. The hot vapours are then passed up a fractionating column made up of stainless steel. When the vapour goes up, it gradually cools down and fractional condensation occurs at different heights in the column. Higher boiling fraction condenses first followed by lower boiling fraction.

Gasoline is obtained between 40 – 120 °C. **Solvent naphtha** is obtained between 120 – 180 °C. **Kerosene oil** is obtained between 180 – 250 °C. **Gas oil** is obtained between 250 – 320 °C.

Cracking of petroleum

- Cracking is the process in an oil refinery by which heavier fraction from the fractional distillation is converted into useful lighter fractions by application of heat, with or without catalyst.
- In other words, cracking is a process by which larger molecules break up into smaller ones.
- Chief application of commercial cracking is for the production of gasoline ($C_5 - C_9$) from gas oils ($C_{10} - C_{18}$).



- Two methods of cracking are:

Thermal cracking: When cracking is carried out without any catalyst at high temperature from 450 – 750 °C at pressure ranging from 1 – 70 atms, it is called thermal cracking. The important reactions are decomposition, dehydrogenation, isomerization and polymerization.

When cracking takes place between 475 – 530 °C temperature its is called liquid phase thermal cracking. When the cracking oil is vaporized and then cracked at 600 – 750 °C, it is called vapour phase thermal cracking.

Catalytic cracking: The use of catalyst during cracking accelerates the reactions and at the same time modifies the yield and the nature of the product. Catalyst used are synthetic composition of silica, zeolites in the form of beads and pellets.

Advantages of catalytic cracking

- Higher yield
- Better quality
- Requirement of low pressure
- No extra fuel necessary, heat required for cracking is derived from coal, embedded in the catalyst
- Low undesirable sulphur content
- Higher aromatic content in the product, hence it possesses better anti-knock characteristics