B. Sc. Part-II (Hons.), Paper-IIIB (Inorganic Chemistry)

Group-C, Unit-3 : Gaseous fuels [By Dr. Birendra Kumar, Maharaja College]

Gaseous fuels are the best fuels. The advantages of gaseous fuels over solid and liquid fuels are: (i) They have high calorific value (ii) They donot produces smoke, leave no ash and there is lesser loss of heat during combustion (iii) No special device are required for their combustion, and can be ignited at any place or any moment. Some important gaseous fuels are: Water gas, Coal gas, Producer gas etc.

⟹ **Water gas**: A mixture of Carbon monoxide (CO) and hydrogen (H_2) is called water gas. It's composition is CO-45%, H_2-50%, CO_2-5%, N_2=5%.

*Preparation: When steam is passed over red hot coke (C), a mixture of CO & H_2 i.e; water gas is formed.

$$\underset{\text{(Coke)}}{C} + H_2O(g) \xrightarrow[\text{Red hot temp}]{1000-1400^\circ C} \underbrace{CO + H_2}_{\text{(Water gas)}}, \quad \Delta H = +28 \text{ kcal}$$

*Properties: 1. It has fairly high calorific value (280-310 BTU/cft ≈ 2700 kcal/mole), and can be increased by adding gaseous hydrocarbons (Carbureting).
2. It burns with blue flame. 3. It is colourless and sparingly soluble in water.

*Uses: It is used (i) as a commercial fuel (ii) in manufacture of H_2, CH_3OH etc. (iii) in welding.

⟹ **Coal gas**: A mixture of gases, e.g. H_2, CH_4, CO, C_2H_4, CO_2, C_6H_6, N_2 & O_2 is called coal gas. Its average composition is: H_2-56%, CH_4-20.8%, CO-10.9, N_2-5%, C_2H_4, C_6H_6-2%, CO_2-1.3%, & O_2-0.5%.

*Preparation: It is prepared by destructive distillation of coal at about 1000°C (i.e; Carbonisation).

*Properties: 1. It is heavier than air and insoluble in water.
2. It is good gaseous fuel of high calorific value (450-500 BTU/cft) as it contains 95% combustible gases. 3. H_2, CH_4 & CO are non-illuminating but heat producing constituents. C_2H_4 & C_6H_6 produce illumination.

*Uses: It is used (i) as a fuel in household and metallurgical operations
(ii) in providing inert atmosphere in certain chemical processes.

⟹ **Producer gas**: A mixture of Carbon monoxide (CO) and nitrogen (N_2) is called producer gas. Average composition of producer gas is: CO-25%, N_2-70%, CO_2-4%, H_2, CH_4, O_2-1%.

*Preparation: It is prepared by the incomplete combustion of coal/coke/charcoal in limited supply of air.

$$C + \underbrace{\tfrac{1}{2}O_2 + N_2}_{\text{Air}} \xrightarrow{\Delta} CO + N_2, \quad \Delta H = -59.4 \text{ kcal}.$$

*Properties: 1. It is poisonous, heavier than air and insoluble in water.
2. It has low calorific value due to presence of large profortion of N_2 in it.
3. It is non-supporter of combustion. 4. On combustion, it produces 59.4 kcal/mol heat.

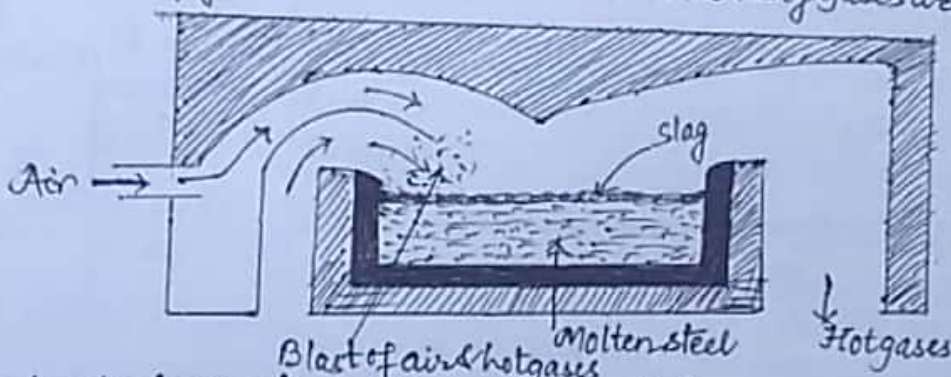
*Uses: It is used as industrial fuel, since it is cheap.

Steel

Steel is a product of almost pure iron (Fe), containing relatively small and varying amounts of Carbon. It is also considered as an alloy of Fe & C. Its avarage composition is Fe = 96.95–98.4%, C = 0.05–1.5%, other impurities upto 1.5%.

* **Manufacture:** The manufacture of steel consists essentially in removing C, Si, P, S etc. from pig iron. These impurities are undesirable, so remove as much as possible. However, a certain amount of C is desirable to modify the properties of iron (Fe). There are several methods employed for manufacture of steel, but following three methods are most common: 1. Bessemer process 2. Open hearth process 3. Electrothermal process.

Open Hearth process: The open hearth process was invented by Siemens & Martin for making a large quantity of steel from pig iron (impure form of iron). In this process, open hearth furnace is used. The hearth is usually lined with burnt dolomite (MgO, CaO) as basic lining. Pig iron is mixed with scrap iron and haemetite (Fe_2O_3). The mixture is melted by forcing pre-heated air and burning gaseous fuels over it. The lining of hearth may also be acidic, such as Silicate bricks depending upon the nature of the impurities in pig iron. Below the tank is a chequerwork of bricks managed in such a way that the heat from the spent gases is used to preheat the entering gases. Combustion takes place rapidly because the gases have been preheated to high temperature. The spent gases are passed through the chequerwork on the other side of the furnace where their heat is imparted to the chequerwork. Every few minutes the direction of gases is reversed so that the incoming gases are always preheated.



The open hearth process thus achieves economy by 'regenerative heating'. When a charge of about 100 tons is melted in the hearth, the iron rust or haemetite may take part in the reaction as under

$$2Fe_2O_3 + 3S \longrightarrow 4Fe + 3SO_2\uparrow, \quad 2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2\uparrow,$$
$$5Fe_2O_3 + 6P \longrightarrow 10Fe + 3P_2O_5, \quad 3CaO + P_2O_5 \longrightarrow Ca_3(PO_4)_2 \text{ (slag)}$$
$$2Fe_2O_3 + 3Si \longrightarrow 4Fe + 3SiO_2, \quad CaO + SiO_2 \longrightarrow CaSiO_3$$

The process is quite slow and chemical analysis can be made periodically to check the composition of the steel. This greater control of composition is perhaps the chief advantage of the open hearth process over the Bessemer process.

* Properties: 1. It is soft, malleable and ductile when % of C is low.
2. It can be forged difficulty, tempered and welded.
3. It can be magnetised permanently.
4. It has highest tensile strength
5. It melts in temperature range 1200–1500°C.

* Uses: 1. In making machinery parts, grinders, bridges, barmagnets, razors etc.
2. In wooden working tools by varying its composition.
3. In construction works.

* Special steels/Alloy steels: To bring about improvement in the properties of steel some alloying materials/metals are added These steels are known as special steels or alloy steels. Some special/alloy steels, their compositions, properties and applications/uses are given below:

Alloying element	Composition	Properties	uses
1. Manganese (Manganese steel)	Fe: 92-88.6%, Mn: 7-10%, C: 1-1.4%	It is very hard & ductile.	It is used for rock crushers, rails, conveyor chains
2. Chromium (Chromium steel)	(i) Fe: 99.2-98.4% Cr: 0.6-1.1%, C: 0.2-0.5%.	It has increased strength and toughness resistant to wear.	It is used for cutting tools, crushers etc.
	(ii) Fe: 95.8-89.8% Cr: 4-10%, C: 0.2%	It has increased hardness and resistance.	It is used for high pressure equipment.
3. Nickel (Nickel steel)	Fe: 97-94.5%, Ni: 2.5-5%, C: 0.5%.	It has increased toughness, hardness and corrosion resisting properties	It is used for constructional work, bridges, Crank shaft, heavy guns etc.
4. Stainless steel	Fe: 87.7%, Cr: 12%, C: 0.3%	It is resistant to corrosion and wear.	It is used for making, Chemical apparatus utensils and in batteries.
5. Tungsten steel	Fe: 78%, C: 1%, W: 17%, Cr: 4%	It is high speed steel, keeps hardness at high temperature	It is used for cutting tools of lathe, drill machin
6. Nickel & Chromium	96.4% Fe, 2.8% Ni, 0.5% Cr, 0.3% C	It is good for case hardening	It is used for parts of aeroplanes and motor cars
7. Copper	Fe: 99.73-99.5% Cu: 0.1-0.2% C: 0.17-0.30%	It has increased corrosion resistant properties.	It is used for bodies of the ocean going vessels.

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