

**GOVT. WOMEN ENGINEERING COLLEGE, AJMER**  
**I Mid Term Assessment Test 2017-18 II Sem(Section – A)**

**Engineering Chemistry**

**B.Tech. II Semester**

**Time : 1.00 hr.**

**8/2/18**

**Max. Marks : 20**

**All questions are compulsory. Schematic diagram must be shown wherever necessary.**

1. Write Dulong formula. 2
2. Define calorific value and establish relationship between LCV and HCV. 2
3. Explain two properties of good fuel. 2
4. Define carbonization of coal and Name types of carbonisation. 2
5. Define temporary hardness and names salts responsible for hardness. 2
6. Write notes on any two: 6
  - (a) Recovery of By-products in Otto Hoffmann's oven method
  - (b) Fractional distillation
  - (c) Beehive oven method
  - (d) Knocking
  - (e) fixed bed catalytic cracking
  - (f) Bergius process
7. 0.26 gm coal sample gave on combustion 0.039 gm of water and 0.245 gm of carbon dioxide. Calculate the percentage of carbon and hydrogen on it. 4

**or**

A sample of coal contains C = 92 %, H= 5% and ash=3%. The following data were obtained when the above coal tested in a bomb calorimeter experiment.

wt. of coal burnt = 0.95gm, wt. of water = 700gm, water equivalent = 2000gm,

Increase in temperature = 2.48° C, Acid correction = 60 cal, cooling correction = 0.02 ° C,

Fuse wire correction = 10 cal.

calculate net and gross calorific value.

## B. Tech. II SEM (17-18)

### CHEMISTRY

#### FIRST MIDTERM

Max. Marks - 20

#### Solutions

1. Dulong's Formula

$$\text{HCV} = \frac{1}{100} [8080C + 34500(H - O/8) + 2240S]$$

Where, C, H, O and S are percentage of carbon, hydrogen, oxygen and sulphur in the fuel respectively.

2. Calorific value is defined as “ the total amount of heat liberated , when a unit mass or volume of the fuel is burnt completely in presence of air.”

$$\text{LCV} = \text{HCV} - \text{Latent heat of steam}$$

$$\text{LCV} = \text{HCV} - (\text{mass of } H_2 \text{ in fuel} \times 9 \times \text{latent heat of steam})$$

$$\text{LCV} = \text{HCV} - (0.09H \times 587) \text{ kcal/kg.}$$

Where, H is percentage of hydrogen in fuel.

3. Properties of a good fuel ( Any 2 ) :

- **Calorific value** : Calorific value is defined as “ the total amount of heat liberated , when a unit mass or volume of the fuel is burnt completely in presence of air.”  
A good fuel should have high calorific value.
- **Ignition Temperature**: It is the lowest temperature to which the fuel must be heated so that it starts burning .
  - A good fuel should have moderate ignition temperature.
  - If the fuel has low ignition temperature the storage and transportation becomes dangerous.
  - If ignition temperature is high then storage becomes easier but it causes difficulty in ignition as most of the heat is utilized in bringing temperature to ignition temperature.
- **Moisture Content** : It should be minimum because presence of moisture content reduces effective calorific value.

- **Non combustible matter content** : It should be low as it lowers down the effective calorific value.
- **Particle size** : The particle size should be uniform for regular combustion.
- **Smoke** produced should be low.
- **Cost** : It should be cheap and abundant.
- **Combustion products** : The gaseous products evolved during combustion shouldn't be harmful.
- **Combustion reaction** : Combustion of a fuel should not be spontaneous because it may cause fire hazards.
- **Velocity of combustion** : It should be moderate. Too high velocity of combustion is not required whereas very low velocity causes loss of heat due to radiation.

4. **Carbonization of coal** : When coal is heated strongly in absence of air, it forms a strong, porous, dense, and coherent mass known as coke or The process of conversion of coal into coke is called carbonization.

There are two types of carbonization:

1. LTC ( Low Temperature Carbonization)
2. HTC ( High Temperature Carbonization)

5. **Temporary hardness** : It is termed temporary since it can be removed by boiling. Temporary hardness is caused by presence of bicarbonates of calcium and magnesium .

The salts responsible for temporary hardness are carbonates and bicarbonates of calcium and magnesium.

## 6. Short notes

### (a) RECOVERY OF BYPRODUCTS IN OTTO-HOFFMANN'S OVEN METHOD:

The gases evolved as a result of carbonization is termed as coke oven gas and it contains large number of byproducts like benzene, naphthalene, ammonia, tar etc. The various steps of byproduct recovery are as follows:

#### -RECOVERY OF TAR:

The coke oven gas is passed through a chamber in which liquid ammonia is sprayed. The tar and dust are removed and then recovered. The tar can be used for road making and for preserving timber.

#### -RECOVERY OF AMMONIA:

The gas is now passed to another chamber where water is sprayed at room temperature and ammonia gas goes into the solution as ammonia hydroxide. Ammonia as ammonium sulphate can be used as fertilizer.

**-RECOVERY OF NAPHTHALENE:**

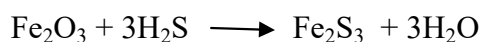
The gas is then passed to another chamber where water is sprayed at very low temperature to condense naphthalene.

**-RECOVERY OF BENZENE:**

Coke oven gas is passed into chamber where petroleum (wash oil) is sprayed as a result benzene and its homologous compounds are recovered with petroleum which can be used as industrial solvent and as raw materials for plastics.

**-RECOVERY OF  $H_2S$ :**

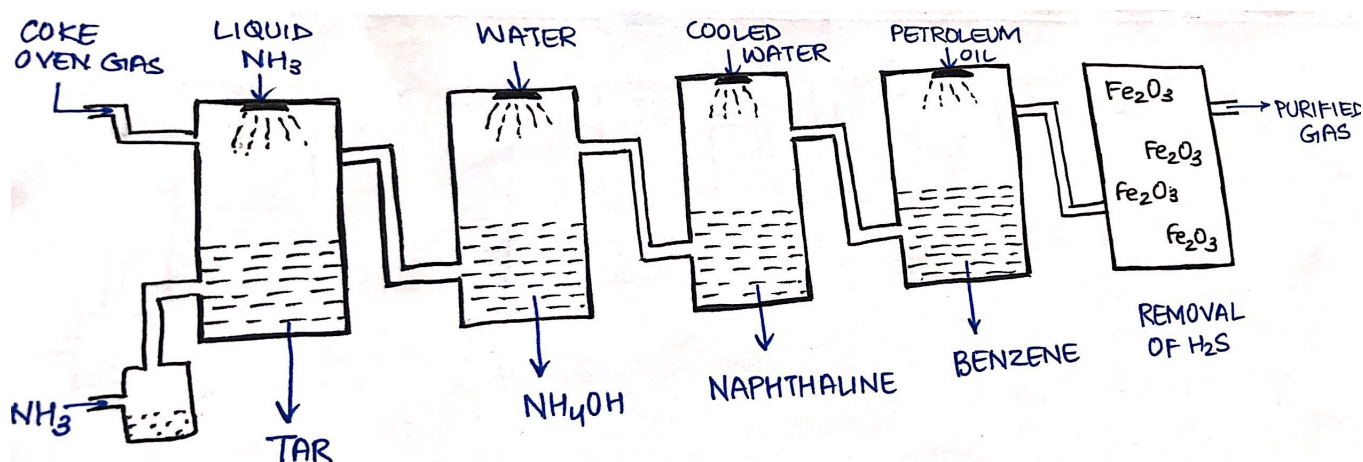
Resultant coke oven gas is passed through another chamber where  $Fe_2O_3$  is applied.



When all the oxide is converted into sulphide it is exposed to air to regenerate  $Fe_2O_3$ .

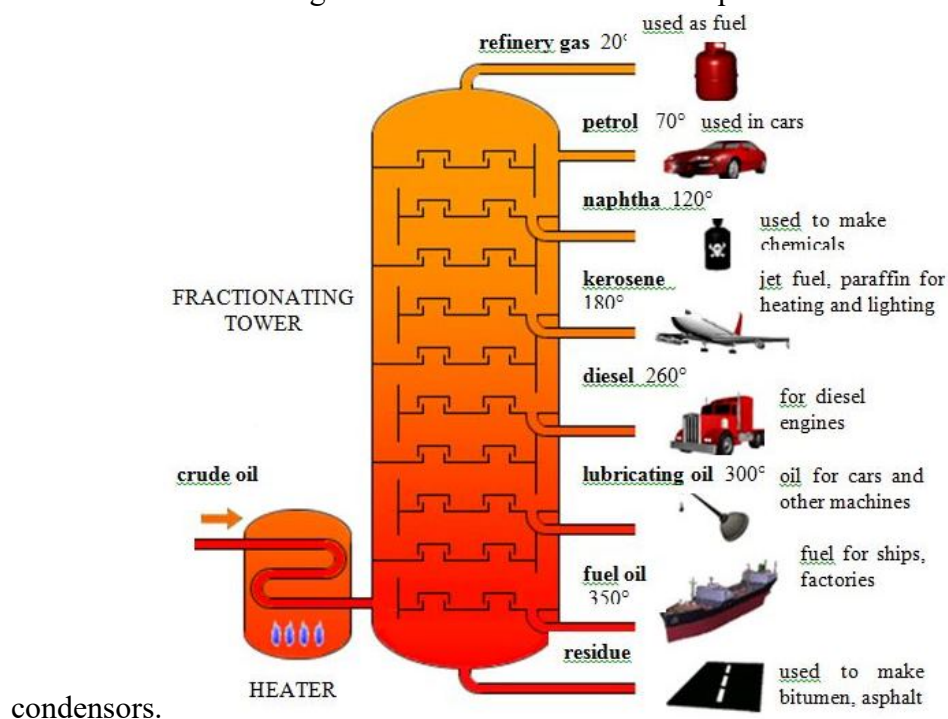
The purified coke oven gas is finally stored in gas holders and can be used as domestic fuel.

**Diagram of Recovery of byproduct in Otto Hoffmann's oven method**



**(b) FRACTIONAL DISTILLATION:**

- 1) It is the process in which different constituents of petroleum or crude oil are separated according to their boiling temperatures.
- 2) The crude oil are heated to about  $400^{\circ}\text{C}$ . At this temperature all volatile constituents are evaporated.
- 3) These vapours are passed in a tall cylindrical tower known as bubble tower which is a tall fractionating column.
- 4) This tower consists of a number of horizontal stainless steel trays. The tray is provided with a small chimney through which vapors rise.
- 5) The separation of various fractions is based on the fact that the hydrocarbons of petroleum boil at different temperature.
- 6) The temperature in the fractionating tower decreases gradually on moving upwards.
- 7) As the vapors rises up in the tower, they become cool and fractional condensation takes place at different height of column.
- 8) Higher boiling fractions condense first at the lower plates whereas lower boiling fractions condense later on the upper plates.
- 9) Thus the crude oil gets separated into different fractions in the order of their boiling ranges selected at different heights in the columns with the help of



**Diagram fractional Distillation**

### (c) BEEHIVE OVEN METHOD

- 1) Beehive oven is the fire brick chamber having a dome shaped structure called as bee hive oven because it resembles bee hive in shape.
- 2) It is 4m wide and 2.5 high.
- 3) Roof is provided with an opening or charging the coal. Another opening is present at the side door which works as inlet of air or outlet of coke.
- 4) Coal is introduced from the top and is spread evenly on the floor of oven till the layer of coal becomes 0.6m high.
- 5) Some air is supplied initially to ignite the coal.
- 6) At the end of carbonization the hot coke is quenched with water and is discharged from side door.

### DEMERITS OF BEEHIVE OVEN METHOD:

- 1) Lower yield of coke due to partial combustion of coal.
- 2) No recovery of byproducts can be done. Byproducts maybe useful but they are allowed to escape.

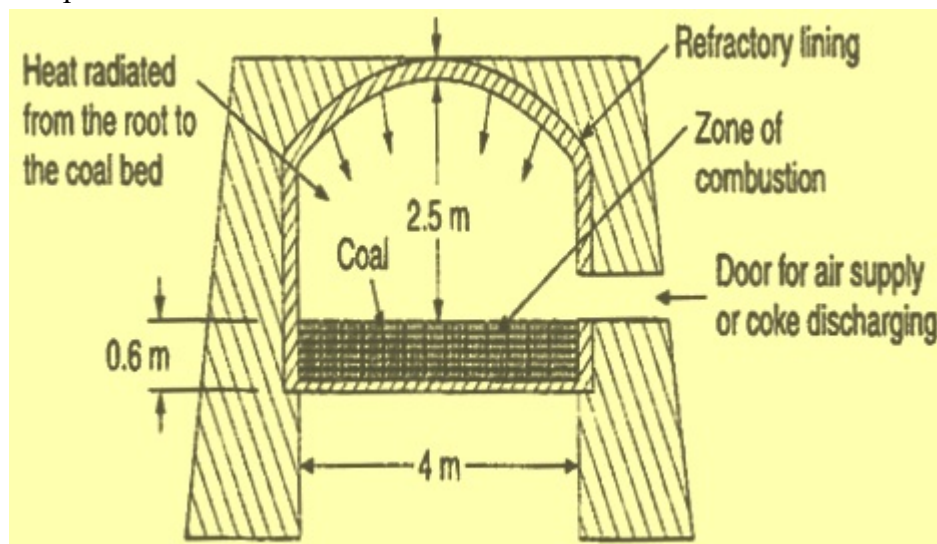


Diagram Bee Hive oven

### (d) KNOCKING :

Knocking is a sharp metallic sound similar to rattling of a hammer produced in internal combustion engines due to uncontrolled combustion of air-gasoline mixture. The fuel used for IC engines is gasoline.

Working involves four stroke cycle ( Otto Cycle )

1. Intake
2. Compression
3. Power
4. Exhaust

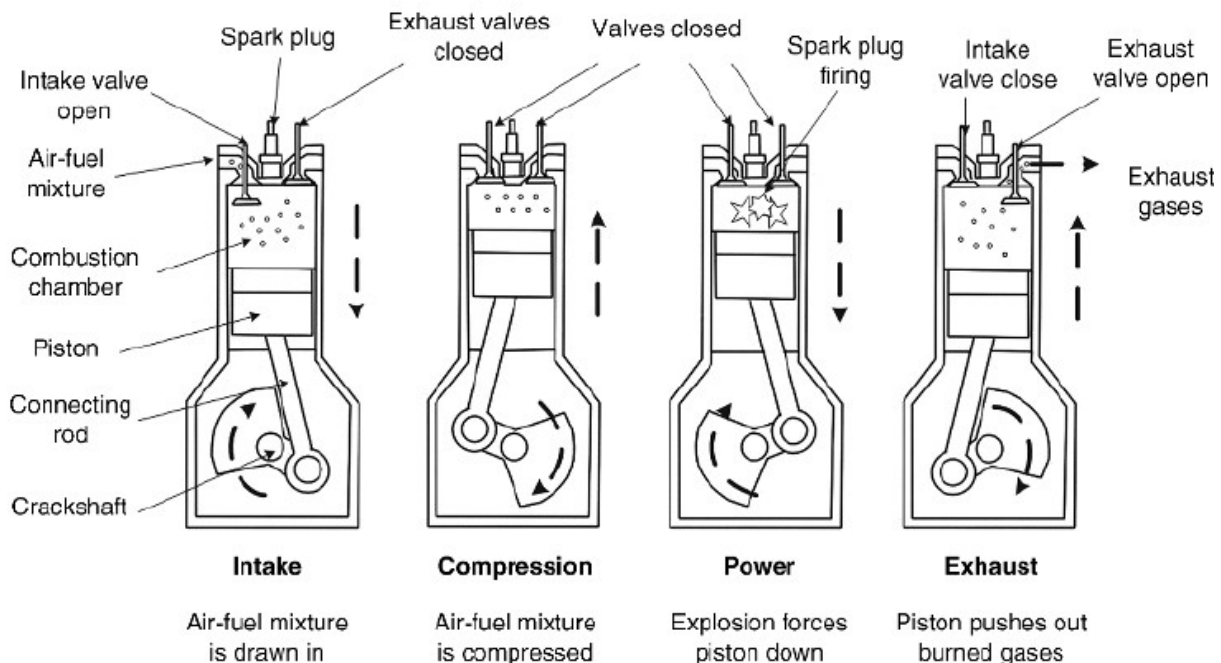
1. **Intake stroke** : This is known as suction stroke as during this stroke piston moves in maximum volume position which is downward direction in cylinder.  
Inlet valve is open. Vaporized fuel mixture enters in the combustion chamber & inlet valve is known as crank- part of engine that translates piston motion into rotator motion.
2. **Compression stroke** : Piston starts its movement in minimum volume position which is upward in cylinder and it compresses the fuel mixture. During this process pressure , temp , and density of fuel mixture is increased.
3. **Power Stroke** : The mixture gets a spark plug and burns the hot gases produced due to combustion increases the pressure and push the piston down.
4. **Exhaust stroke** : Exhaust valve is open & piston starts its movement in minimum volume position . It expels the exhaust . The efficiency of the engine increases with compression ratio .

$$\text{C.R.} = \frac{\text{Gaseous volume at the end of suction}(V_2)}{\text{Gaseous volume at the end of compression}(V_1)}$$

If the C.R. exceeds a certain limit ( Critical Compression Ratio) , preignition of the fuel takes place i.e., fuel ignites even before the regular spark. This is premature ignition.

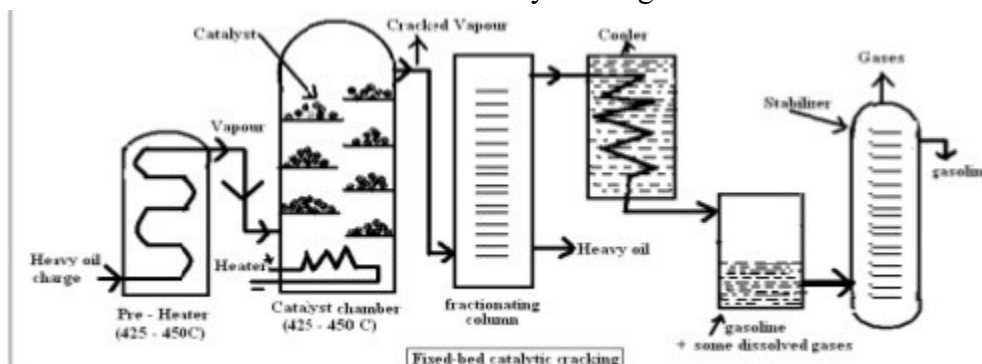
As a result fuel burns in explosive manner & produces violent sound called knocking.

#### Four-stroke cycle (Gasoline)



**(e) FIXED BED CATALYTIC CRACKING :**

- This type of cracking is called as fixed bed catalytic cracking because the catalytic chamber contains the catalyst in form of fixed beds.
- The heavy oil is preheated to  $425-450^{\circ}\text{C}$  & then forced to catalytic chamber.
- Cracking takes place & cracked vapours are passed through the fractionating column.
- Here , gasoline vapours are recovered for the top & heavy oil , condensed & is removed.
- The gasoline vapours are passed into a cooler where vapours along with some dissolved gases are removed.
- During cracking , carbon particles get deposited on the catalyst & it stops working after about 10 to 11 hours. This is reactivated by burning off carbon.



**Diagram Fixed bed catalytic cracking**

**(f) BERGIUS PROCESS ( DIRECT COAL LIQUIFICATION) :**

This method involves production of gasoline by destructive hydrogenation of coal where conversion of low grade “bituminous coal” into liquid & gaseous fuel takes place by hydrogenation in presence of catalyst.

**PROCESS :**

- A paste of finely powdered coal is made with heavy oil & catalyst is added.
- The above mixture of paste is heated with it at  $450^{\circ}\text{C}$  for about two hours.
- Saturated hydrocarbons are formed which on cracking gives low boiling liquid hydrocarbons.
- The gases are passed through a condenser where a liquid resembling crude oil is produced .
- The crude oil is fractionated to yield gasoline , middle oil , & heavy oil.
- The middle oil is further hydrogenated in presence of catalyst to produce gasoline.
- Heavy oil is again reused for making paste with coal.

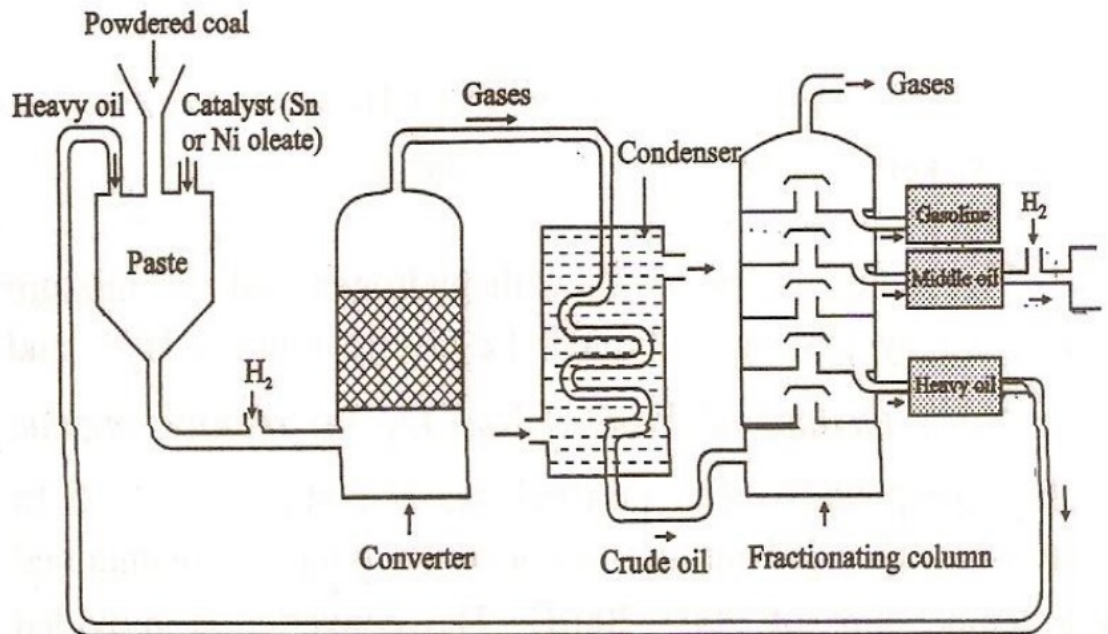


Diagram BERGIUS PROCESS

7.  $X = 0.26 \text{ gm}$  ,  $\text{H}_2\text{O} = 0.039 \text{ gms}$  ,  $\text{CO}_2 = 0.245 \text{ gms}$

% of C is given by  $= \frac{12 \times b \times 100}{44 \times X}$

$$= \frac{12 \times 0.245 \times 100}{44 \times 0.26}$$

$$= 25.69 \%$$

Where  $b = \text{CO}_2$  absorbed

% of  $\text{H}_2$  is given by  $= \frac{a \times 100}{9x}$

$$= \frac{0.039 \times 100}{9 \times 0.26}$$

$$= 1.66 \%$$

OR

$\text{C} = 92\%$  ,  $\text{H} = 5\%$  ,  $\text{Ash} = 3\%$  .

Weight of coal burnt =  $0.095 \text{ gm}$

Weight of water =  $700 \text{ gm (W)}$

Water equivalent = 2000 gms (w)

Increase in temp (  $t$  ) =  $2.48^{\circ}\text{C}$

Acid correction = 60 cal

Cooling correction =  $0.02^{\circ}\text{C}$

Fuse wire correction = 10 cal

Acc. to formula ,

$$C = \frac{(W + w) \{(t_2 - t_1) + \text{cooling correction}\} - (\text{Acid correction} + \text{fuse wire correction})}{\text{Mass of the fuel x}}$$

$$C = \frac{(700 + 2000) (2.48 + 0.02) - (60 + 10)}{0.095}$$

$$= \frac{(2700) (0.0496) - (70)}{0.095}$$

$$= \frac{63.92}{0.095}$$

$$= 7031.57 \text{ cal/g}$$

$$\text{LCV} = \text{HCV} - (0.09 \times \text{H} \times 587) = 672.842 - (0.09 \times 5 \times 587)$$

$$= 672.842 - (5 \times 587)$$

$$= 672.842 - 264.15 = 6767.45 \text{ cal}$$