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Assignment 4.

1. What are the types of fuel & characteristics of good fuel?

→

Fuels are the source of heat energy, these are substance containing carbon as main constituent and other atoms which on combustion produce heat energy that can be used as domestic & industrial purpose.
Fuels may be classified into two types :
1) Primary fuel
2) Secondary fuel

1) Primary Fuel :

i) It is also known as natural fuel.
ii) Natural fuels are directly used for the function of heat & its technical utilization as such it may be solid, liquid or gas.
iii) Ex. Solid fuel - wood, coal, lignite
Liquid fuel - petrolieum
gas - Natural gases.

2) Secondary Fuel :

i) Secondary Fuel are also known as artificial or manufactured or processed fuel.
ii) Secondary fuel are those which are obtained from primary fuel. It may be solid, liquid, gas.
iii) Ex. Solid fuel : Higher or low temp coke, charcoal, etc.
Liquid fuel : Kerosine, disel, gasoline, L.P.G, etc.
Gaseous Fuel : Coal gas, water gas, bio-gas, etc.

Characteristics of a good fuel :

i) The fuel should have colorific value i.e high heat content.
ii) The moisture content should be low as moisture lowers the calorific value.
iii) The egination temp should be low so that it can be burn smoothly.
iv) A fuel should have low content of non-combustable matter because non-combustible matter also reduces the heating value.
v) A good fuel should be readily available in bullk at low cost.
vi) Storage cost in bulk should be low.
vii) In case of solid fuel, the ash content should be less and the size should be uniform.
viii) The velocity of combustion should be moderate.
ix) Combustion product shouldn't be harmful.
x) Combustion should be easily controlable.
xi) In case of liquid & gas fuel combustion shouldn't be spontenceous.
xii) A good fuel should burn efficiently without smoke.
xiii) The supply position of fuel should be reliable.

2. Explain in detail the Proximate Analysis of coal with its significance.

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i) It involves the determination of % of moisture, percentage of volatile matter, % of fixed carbon & % of ash.

1. Moisture Content:

A known weight of coal (air-dried) is taken in a crucible & heated in an electric hot air oven at about 105°C - 110°C for about 1hr. After 1 hr, it is taken out from the oven & cooled in a dessicator and weighed. Loss in weight of the sample is found out and the percentage of moisture is calculated as follows:

Let weight of coal sample = W g
Weight after heating for 1h = W_1 g

Loss in weight, that is the weight of moisture = $(W - W_1)$ g

$$\% \text{ of moisture} = \frac{(W - W_1)}{W} \times 100$$

Significance:

1) High moisture content is undesirable because it reduces the calorific value and increases the transportation cost.
2) Presence of ~~exercise~~ excessive moisture quenches fire in the furnace.

2. Volatile Matter:

It is determined by heating a known weight of moisture-free coal in a silica crucible covered with a vented lid at $950 \pm 20^{\circ}C$ for 7 min in a muffle furnace. The crucible is then taken out and cooled inside a dessicator and weighed again. Complete removal of volatile matter is judged by bubbling the gas through a water seal. Loss in weight of the volatile matter & the percentage of volatile matter is calculated as follows.

Let the weight of sample after removal of volatile matter $= W_2$ g.

weight of volatile matter $= (W_1 - W_2)$ g

$$\% \text{ of volatile matter} = \frac{(W_1 - W_2)}{W} \times 100$$

Significance:

1) A high percentage of volatile matter indicates that a large proportion of fuel is burnt as gas.
2) Low volatile matter containing coals do not cake at all & are thus unsuitable for coke making.
3) If the furnace volume is small or flame is short, a large proportion of volatile matter will escape unburnt.

3. Ash

Ash content is determined by heating the residue obtained after removal of moisture & volatile matter at 700 ± 50°C for half an hour without a lid in muffle furnace. The residue left is cooled in dessicator and weight. From the weight of residue, the % of ash is calculated as:

Let weight of ash formed = w_3 g

$$\% \text{ of ash} = \frac{w_3}{w} \times 100$$

Significance:

1) High percentage of ash is undesirable as it reduces calorific value.
2) Presence of ash increases transporting, handling & storage cost.
3) It also involves additional cost of ash disposal.

4. Fixed Carbon

Fixed Carbon is the material remaining after determination of moisture, volatile matter & ash content. It is determined indirectly by the formula.

% of fixed carbon = 100 - % (moisture + volatile matter + ash).

Significance:

1) Higher the % of fixed carbon, greater the calorific value.
2) Coals with high fixed carbon content are difficult to ignite but they burn slowly.
3) The % of fixed carbon helps in designing the furnace.

3. Explain types of coal with their characteristics and uses.

→

i) Coal is classified on the basis of carbon contain present in it.
ii) It is obtained from polification from wood.
iii) The composition of wood is C = 50%, H = 6%, N = 0.5%, O = 43.5%.
iv) The calorific value of wood is 4K - 4.5K kcal/kg.
v) The evolution of coal occurs as follows :
Wood → Peat → lignite → Bituminous → Anthracite.

Type of Coal	Characteristics & uses	Composition	Colorific Value
1) Peat	i) Brown fibrous jelly-like mass ii) Uneconomical fuel contain 80-90% water needs 1-2 months air drying for free bumping.	C = 57%. H = 5.7%. N = 2%. O = 35.5%	4125 - 5400 kcal/kg
2) lignite	i) Soft, brown-colored, compact in texture. ii) Contain 20-60% moisture on air drying breaks into small pieces. burns with long flame	C = 67%. H = 5%. N = 1.7%. O = 26.5	6500 - 7100 kcal/kg.
3) Bituminous	It is further classified -		
a) Sub-bituminous	i) Black in color, more homogeneous smooth in nature. ii) On exposure in air crumble into small pieces.	C = ~~83%~~ 77%. H = 5%. N = ~~2%~~ 1.8%. O = ~~10%~~ 16.2%	7000 - 7500 kcal/kg.

b) Bituminous	i) Used for making metallurgical coke, coal gas, for steam rising and domestic heating ii)	C = 83 %. H = 5 %. N = 2 %. O = 10 %.	8350-8500 kcal/kg
c) Semi-Bituminous	i) Used for coke manufacture	C = 90 %. H = 4.5 %. N = 1.5 %. O = 4 %	8350-8500 kcal/kg.
d) Anthracite	i) Hardest, quite dense & lustrous in appearence. ii) Burn without smoke, give intense local heating. iii) Possess no caking power iv) Used for steam raising, household purpose & in metallurgical process	C = 93.3 %. H = ~~4.5~~ 3 %. N = 0.7 %. O = 03 %.	8650-8700 kcal/kg.

4. Write a note on types of lubricants.

→

Any substance introduce between 2 moving surfaces with a view to reducing the frictional resistance is known as lubricant.

Types of Lubricant:

A) Solid Lubricants
B) Semi-Solid lubricants
C) Liquid Lubricants.
D) Emulsion.

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Solid Lubricant :

This solid state lubricants are used in
1) Machines used at high load and low speed.
2) Machines where a semi-solid or liquid lubricant can't
3) In part of machine which needs lubrication.

i) They are used only in special cases as many of them may damage delicate machine part due to presence of grains or particles.
ii) The most widely used are graphite (powder, collide form) and MoS_2 (powder form) both having laminal layer, lattice structure & used at high temp & pressure.
iii) Graphite has sp^2 hybradise carbon atom which are organised / arranged in regular hexagon in flat parallel layers.
iv) In graphite, no strong bonding bet^n layers and easily sliding possible giving lubricating property.
v) Graphite preparation is made into dispersion with 'water dag' and with oil named 'oil dag'.
vi) Aquadag is used in process where a lubricant is free from oil is needed.
Oil dog is used in internal combustion engine.
vii) MoS_2 consist of a layer of Molebinal atoms which is sandwich bet^n 2 layers of S atoms.
There is weak force of attraction bet^n 2 layers which gives easy sliding and hence the lubricating property.

viii) MoS_2 preparation are available commercially as molykotes.

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Semi-Solid Lubricants :

Greases are the most common examples of semi-solid lubricants. They are oils made semi-solid by adding a thickening agent. The thickners dispersed in the lubricating oil produce a stable and colloidal structure or gel. Grease contain 3 basic active ingrediants : a lubricating oil, additive and thickners.

- Greases are generally used in textile mills, paper mills and mills of edible articles where use of liquid lubricants can cause contamination of the products by spilling or dripping.
- Machines like rail axle boxes work at slow speed & high pressure, intermittent operation and sudden jerks. In such conditions, oil can't remain in its place.
- In bearing and gears working at high temp.
- Used in bearings which need to be sealed against the entry of dust, grit, moisture.

Greases are classified on the basis of the soap used in their manufacture :

Type of grease	Chemical composition	Characteristic properties.
1) Calcium based grease	Emulsions of petroleum oils with calcium soaps	i) Insoluble in water hence water resistant. Since oil and soap separate above 80°C. They are suitable for water pumps, tractors, etc.

Type of grease	Chemical composition	Characteristic properties
~~Lithium~~ Soda based greases (Na)	Peteroleum oil thickned by mixing ~~lithium~~ Sodium soap	Not water resistant because sodium content of soap is soluble in water; they can be used upto 175°C; they are suitable for use in ball bearings where the lubricants gets heated due to friction
Lithium based greases	Peteroleum oil thickened by mixing lithium	Water resistant but can be used up to 15°C only. They are expensive.

c) Liquid Lubricants :

i) Liquid lubricants reduce friction and wear & tear betⁿ two metal surfaces by providing a continuous layer betⁿ them.

ii) Liquid Lubricants can be further subdived into 3 types:

a) Mineral oils or petroleum oils :

i) These oils are obtained by fractional distillation of crude petroleum. On being subjected to vaccum distillation, the heavy residual fraction yields lubricating oil.

ii) The hydrocarbon chain is 12 to 50 carbon atoms long.

iii) They are widely used as lubricants because they are cheap, abundant and stable under working conditions.
iv) They have poor oiliness as compared to vegetable oils.

b) Animal & Vegetable oils :
i) These are extracted from animal and vegetable matter and contain glycerides of higher fatty acids.
ii) They are known as 'oiliness', a property by which they stick to the metal surface even under high temp and high load.
iii) However, they have certain limitations. Such as,
- They are expensive; undergo oxidation to form gummy and acidic product; they oxidize in contact with air and become thick.

iv) The commonly used animal & vegetable oils are olive oil, mustard oil, palm oil, whale oil, etc.

c) Blended oils :
i) Blended oils are termed as doped oils or compounded oils. No single oil can serve as a satisfactory lubricant under all conditions. Hence, their properties are improved by adding certain additives. This phenomenon is called 'blending'.
ii) The additives used as follows :
① Antioxidants or inhibitors : They retard the oxidation of lubricating oils by getting themselves preferentially oxidised.
② Oiliness carriers : They increase the oiliness of lubricant These carriers are added in lubricants used in boundary lubrication.
③ Viscosity index improvers : They increase the viscosity index & are added in lubricants used in ~~boundary lubrication~~. machines working under a broad temp range. Ex. hexanol.

5. Describe the process of determination of % of C, N & H in coal.

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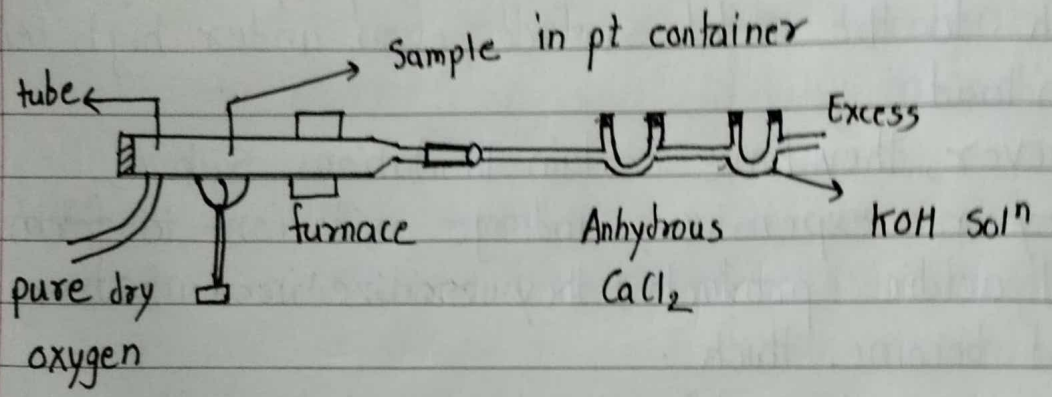
The process to find % of C, N & H in coal also called as Ultimate analysis of coal.

a) Carbon & Hydrogen :



i) C & H elements present in coal can be determined by heating a known amount of sample of coal in current of oxygen in combustion apparatus as a result C & H present in coal are converted into CO_2 & H_2O.

ii) These absorbs in KOH & $CaCl_2$ of known weight.

iii) The increasing weight of gives the amount of CO_2 & H_2O form.

$$C + O_2 \longrightarrow CO_2$$

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

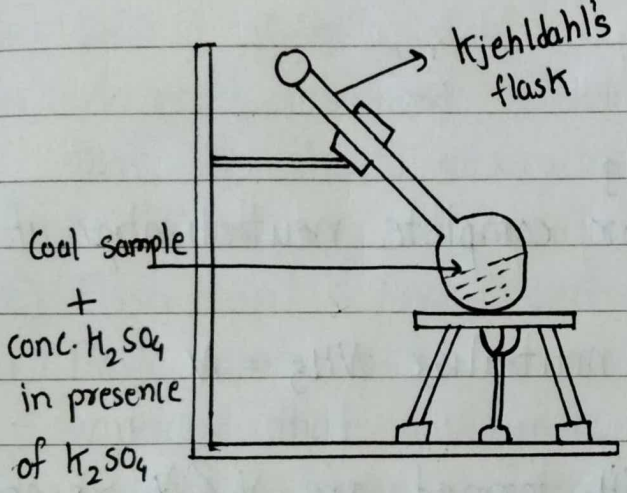
$$H_2 + \tfrac{1}{2}O_2 \longrightarrow H_2O$$

$$CaCl_2 + 7H_2O \longrightarrow CaCl_2\ 7H_2O$$

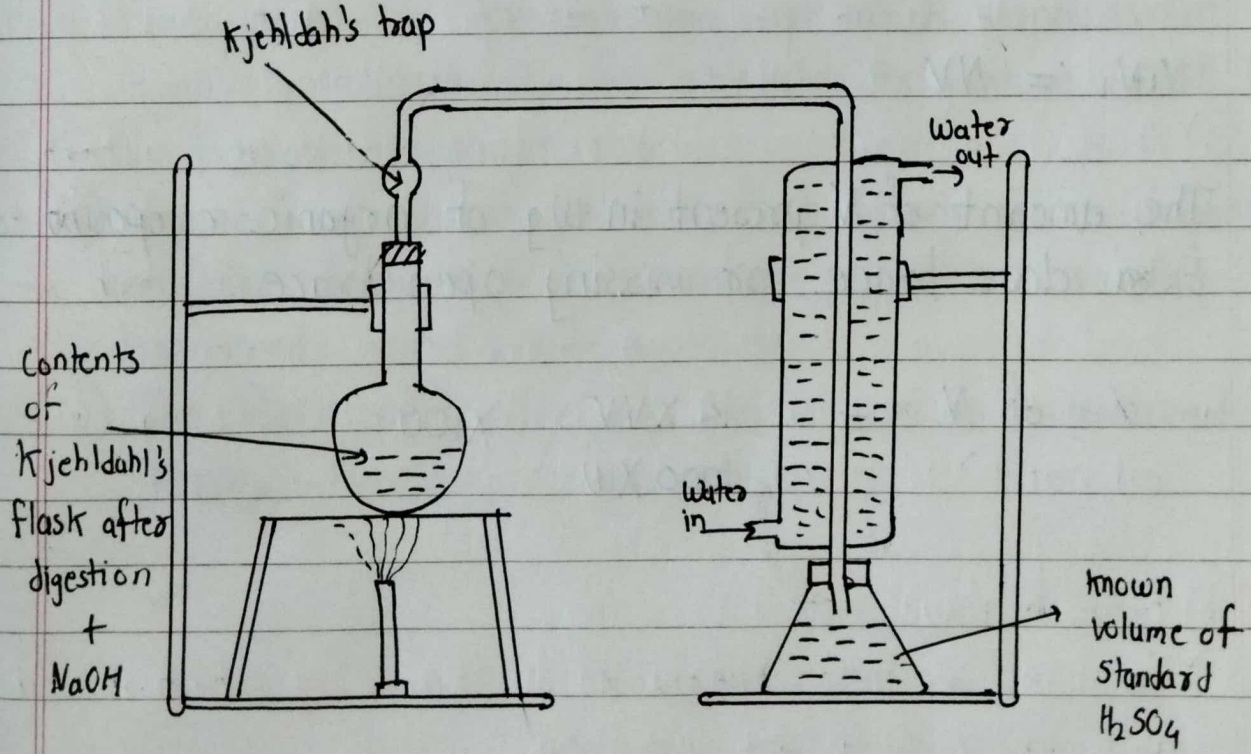
% of Carbon = $\frac{12 \times \text{increase of wt of KOH}}{44 \times \text{wt of coal sample taken}} \times 100$

% of Hydrogen = $\frac{2 \times \text{increasing weight of } CaCl_2}{18 \times \text{wt of sample taken of coal}} \times 100$

b) Nitrogen –



substance + conc. H_2SO_4 + K_2SO_4



i) This method is based on the fact that an organic compound containing N is heated conc. H_2SO_4. The nitrogen is converted into ammonium sulphate.
ii) The resultant liquid is heated with excess of alkali & then liberated ammonia gas is absorbed in excess of standard acids.
iii) The amount of ammonia is determined by finding the amount of acid neutralised by back titration with same standard alkali

Calculation:
Wt. of substance = W g
Vol. of H_2SO_4 required for complete neutralisation of evolved NH_3 = V
Strength H_2SO_4 used to neutralise NH_3 = N

Let vol. & strength of NH_3 formed are V_1 & N_1 respetively.

$V_1N_1 = NV$

The amount of N present in W g of organic compound =
Extra close brace or missing open brace.

$$\% \text{ of } N = \frac{14 \times NV}{1000 \times W} \times 100$$

6. Discuss any 3 physical properties of lubricants.

→

1) Surface Tension :

i) Surface Tension is an invert force experienced per unit area by the liquid & its surface because of higher attraction within the liquid molecule than the attraction of liquid with the air.

ii) A tension is developed on surface due to inbalenced forces with its

iii) Unit : N/m^2

iv) A good lubricant should have low surface tension so that it should spray over a large area.

2) Flash point & Fire point

i) Flash point is the min temp at which liquid gives of vapours that will egnite for a moment when small flame is brought near it.

ii) Fire point is the min temp at which vapours of oil burns continuously for atleast 5s. when small flame is brought near it.

iii) A good lubricant possess flash & fire point higher than working temp of the machine thereby avoiding fire hazzards and ensuring safety.

iv) The flash point or fire point can be measured in Pensky-Marten's apparatus.

3) Cloud point & pour point:
i) Cloud point is temp at which oil becomes cloudy or hazy in appearence
ii) Pour point is temp at which oil ceases to flow or pour.
iii) A good lubricant must have low cloud & pour point or else it makes solidify at working temp causing jamming of machine parts.
iv) A cloud point & pour point measured with a cloud or pour point apparatus.

7. Discuss all the chemical properties of lubricants.
→

a) Acid Value:

i) Acid value is the no. of mg of KOH required to neutralize free fatty acids present in 1gm of oil.
Unit: mg of KOH/g
ii) A good lubricant should have low acid value, a high acid value indicates presence of free fatty acids should be taken as an indicator of oxidation of oil which may lead to gum, sludge formation beside corrosion.
iii) When a acid value of oil is more than 0.1 mg of KOH/g oil can't be used as l

b) Emulsification:
i) Emulsion is the property of lubricant by which mixed with water & forms emulsion.
ii) Pure oil & water separate into 2 layers when mixed but oil shows presence of dust, metal particles, acid or alkali.

The rate of separation of 2 layers ~~when mixed but oil shows presence of dust~~ decreases & emulsion is formed.

iii) Emulsion have tendency to collect dirt particles which can cause abrestion & also forms sludge which clogs oiliness.

iv) Hence, it is necessary that a lubricant oil should be break away from emulsion in an emulsion is formed.

v) This property of oil to separate out from an emulsion is known as 'demulsification no.' and it is determined by counting the time required in s. for the given volume of an oil to separate out distinctly from an equal vol. of condensed steam under standard.

vi) A good lubricant oil must have low demulsification no; means oil separate out from the emulsion quickly.

c) Saponification

i) Saponification value is the no. of mg KOH of required to saponify 1gm of oil.

ii) Saponification is hydrolysis of an oil with KOH to give glycerol and K salt, fatty acids (unit : mg of KOH/g)

iii) A good lubricant should have low saponification. Moreover, it predicts the ~~solubility~~ stability of a lubricant in ageous or alkaline medium.

8. Discuss the ultimate analysis of coal in detail.

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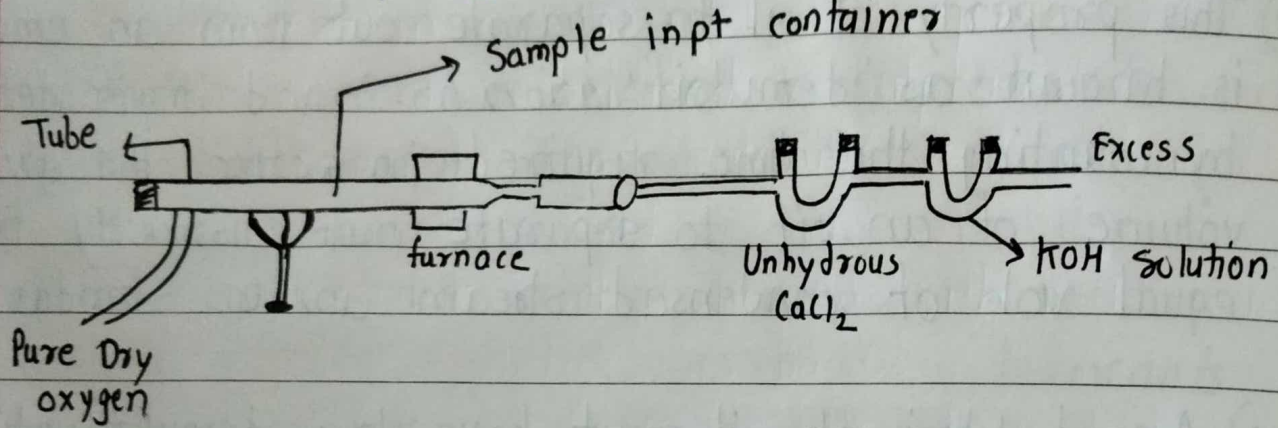
i) It is also called as elementary analysis.
ii) It includes the determination of percentage O_2, C, H, S and phosphorus in the coal.

a) Carbon & Hydrogen



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b) Nitrogen

i) This method is based on the fact that an organic compound containing nitrogen is heated with conc. H_2SO_4. the nitrogen is converted to ammonium sulphate.
ii) The resultant liquid is heated with excess of standard acid.
iii) The amount of ammonia is determined by finding the amount of acid neutralised by back titration with same standard alkali.

Calculation:
Weight of the substance = Wg
Vol. of H_2SO_4 required for complete neutralisation of evolved NH_3 = N

Let the vol & strength of NH_3 formed are V_1 & N_1 respectively
$V_1N_1 = VN$

The amount of N present in Wg of organic compound
= Extra close brace or missing open brace.

$$\% \text{ of } N = \frac{14 \times NV}{1000 \times W} \times 100$$

c) Sulphur

i) Sulphur is found in coal in three forms, as organic sulphur compounds, as inorganic sulphides and also as inorganic sulphates.

ii) To estimate the amount of sulphur in the coal sample a known amount of coal is burnt completely in a bomb calorimeter in a current of oxygen.

iii) Sulphar in coal is oxidised to sulphates

iv) The ash from the bomb calorimeter is extracted with dilute hydrochloric acid.

v) The acid extract is then treated with $BaCl_2$ solution to precipitate sulphate as $BaSO_4$.

vi) The precipitate of $BaSO_4$ is filtered, washed, dried and heated to a constant weight.

vii) From the weight of $BaSO_4$ formed S is estimated as follows:

$$\underset{32}{S} \xrightarrow{O_2} SO_4^{2-} \xrightarrow{BaCl_2} \underset{233}{BaSO_4}$$

Let weight of coal sample = W g

weight of $BaSO_4$ = x g

$\therefore$ 233 g of $BaSO_4$ = 32 g of S

$\therefore$ x g of $BaSO_4$ = $\frac{32}{233} \times x$.

$$\% \text{ of } S = \frac{32}{233} \times \frac{x}{w} \times 100$$

D) Ash :

$$\% \text{ of ash} = \frac{\text{Weight of ash formed}}{\text{weight of coal sample}} \times 100$$

E) Oxygen :

i) It occurs both in organic and inorganic portions of coal and is determined indirectly by deducting the % of C, H, N, S and ash from 100.

$$\% \text{ of oxygen} = 100 - \% \text{ of } (C + H + N + S + \text{ash}).$$

98. Discuss the process of refining of petroleum in detail.

→ i) Crude oil coming out from the oil well is a mixture of solid, liquid and gaseous hydrocarbons containing sand and water in suspension.

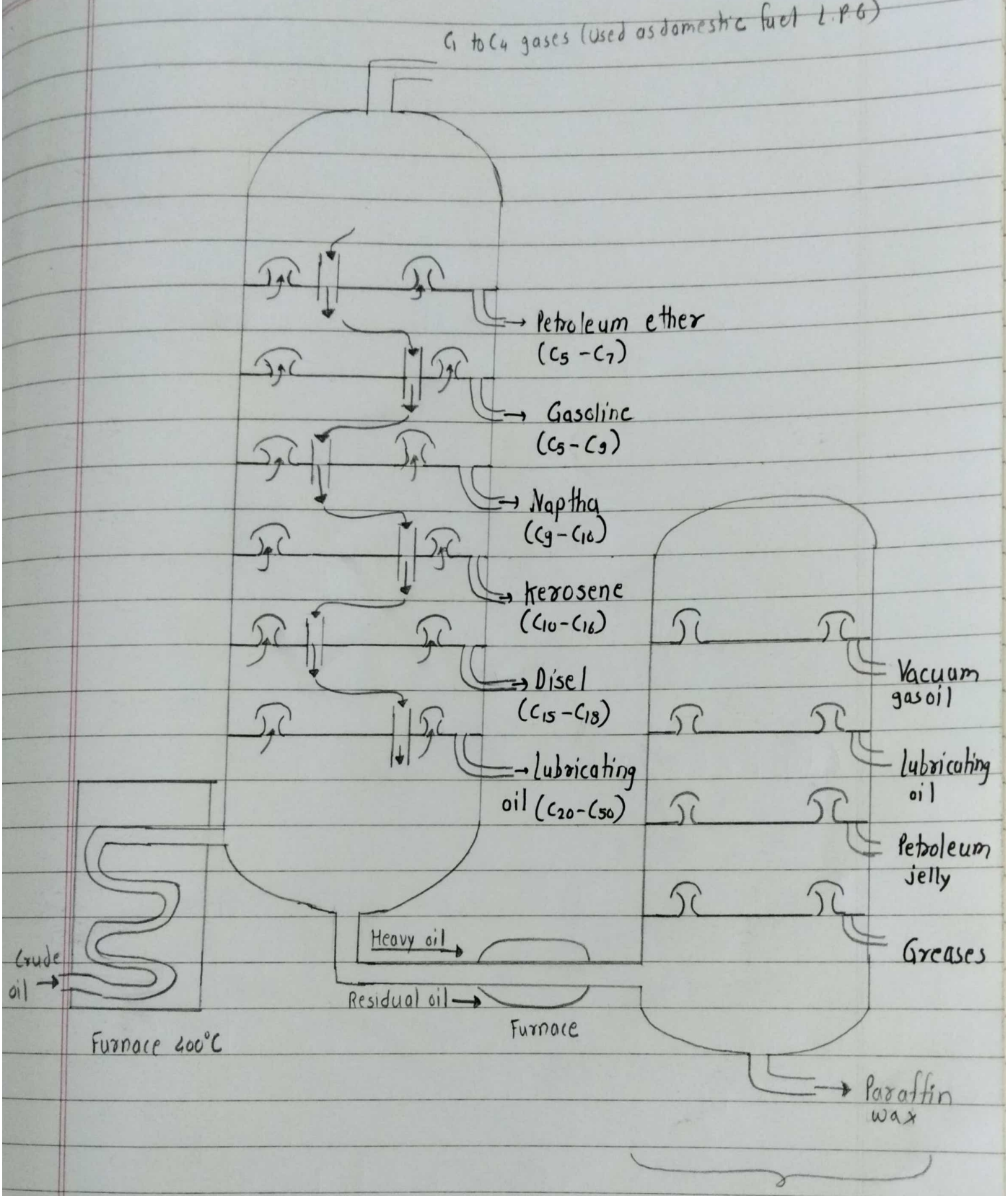
ii) After removal of dirt, water, sulphur and other impurities, this oil is subjected to fractional distillation.

iii) This process of removing unwanted impurities and separating petroleum into useful fractions with different boiling ranges is called Refining of petroleum.
iv) The process of refining involves the following steps:

① Separation of water (demulsification):
i) The crude oil from the well is an extremely stable emulsion of oil & salt water. The demulsification is achieved by Cotrell's process.
ii) The crude oil is allowed to flow between two highly charged electrodes where colloidal water droplets coalesce to form large drops which separate out from oil.

② Removal of harmful impurities:
i) NaCl and $MgCl_2$ corrode the refining equipments. These are removed by modern techniques like electrical desalting & dehydration.
ii) Harmful S compounds are removed by treating the crude oil with Cu oxide. S reacts with Cu oxide forming Cu sulphide, removed by filteration.

③ Fractional Distillation: ① The crude oil is heated to 400°C in an iron retort whereby all volatile constituent, except asphalt or coke are evaporated. The vapours are then passed into a fractionating column, which is a tall cylindrical tower. The tower is hot towards lower end and cooler at upper end. It consists of a no. of horizontal stainless steel trays at short distances. These trays are provided with individual chimneys which are covered with loseca As the vapours go up, fractional condensation occurs at different heights of the column. Higher boiling fractions condense first, while lower boilings fractions are condensed later.



Vaccum distilation of residual oil.