Unit
16

Chemical Industries

Long Answer Questions

Q.1 Describe in detail the various process involved in the concentration of ore explain your answer with the help of diagram.

Ans. Concentration of the Ore

The process of removal of gangue from the ore is technically known as concentration and the purified ore is called the concentrate. Concentration of the crushed ore is carried out by the following methods:

a) Gravity separation

Gravity separation is based on the differences in densities of the metallic ore and the gangue particles.

In the process, the powdered heavy metal bearing ore settles down on agitation in a stream of water, while the lighter gangue particles are carried away by the water as shown in figure

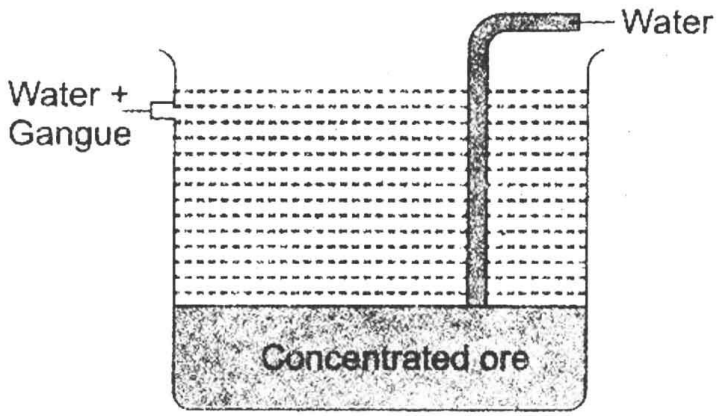


Fig. Gravity separation

b) Froth flotation process

Froth flotation process is based on the wetting characteristic of the ore and the gangue particles with oil and water, respectively.

The ore particles are preferentially wetted by oil and the gangue particles by the water. The whole mixture is agitated with compressed air. Hence, oil coated ore particles being lighter come to the surface in the form of a froth that can be skimmed as shown in figure:

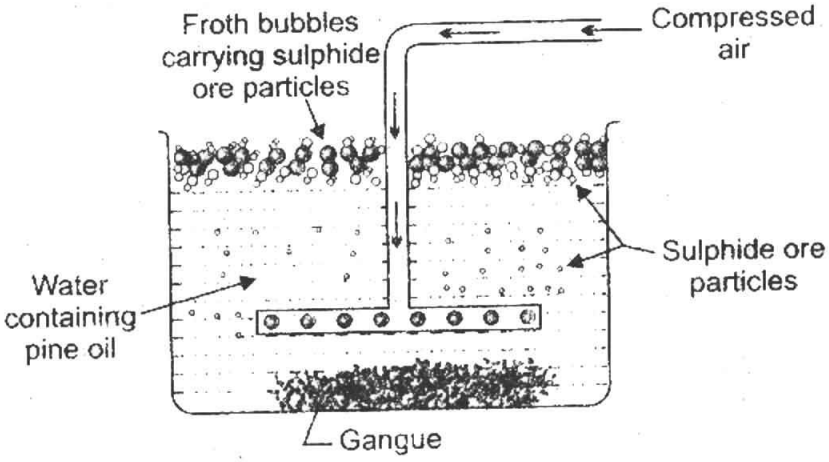


Fig: Froth flotation process

c) Electromagnetic separation

Electromagnetic separation is based on the separation of magnetic ores from the non-magnetic impurities by means of electro-magnets or magnetic separators.

The powdered are is dropped over a leather belt moving over two rollers, one of which is magnetic. The one gets attracted and is collected nearer to the magnet while the non-magnetic impurities fall further away as shown in figure

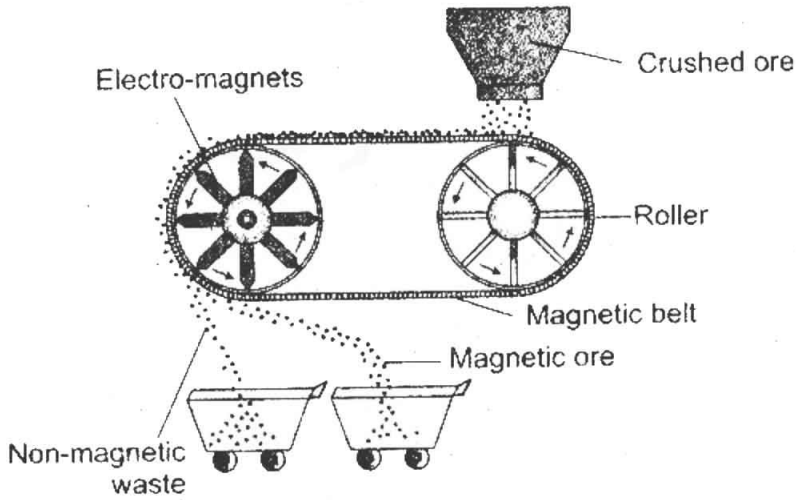


Fig: Magnetic separation

Q.2 Explain the process of roasting.

Ans. Roasting

It is a process of heating the concentrated ore to a high temperature in excess of air.

Example

copper pyrite ($CuFeS_2$) is strongly heated in excess of air to convert it into a mixture of cuprous sulphide and ferrous sulphide ($Cu_2S + FeS$). While impurities react with oxygen to form volatile oxides. Such as

$$2CuFeS_{2(s)} + O_{2(g)} \longrightarrow Cu_2S_{(s)} + 2FeS_{(s)} + SO_{2(g)}$$

Q.3 Write a note on smelting and bessemerization, giving a specific examples.

Ans. Smelting

It is the further heating of the roasted ore, sand flux and coke in a blast furnace in the presence of excess of air.

It is highly exothermic process, therefore, a small amount of coke is required in the process. In the process, first ferrous sulphide oxidize to form ferrous oxide which reacts with sand to form iron silicate slag ($FeSiO_3$). It being lighter rise to the top and is removed from the upper hole.

$$2FeS_{(s)} + 3O_{2(g)} \longrightarrow 2\,FeO_{(s)} + 2SO_{2(g)} \uparrow$$

$$FeO_{(s)} + SiO_{2(s)} \longrightarrow FeSiO_{3(s)}$$

On the other hand, cuprous sulphide also oxidize to form cuprous oxide which reacts with ureacted ferrous sulphide to form ferrous oxide and cuprous sulphide. In this way, cuprous sulphide and ferrous sulphide form a mixture ($Cu_2S.FeS$). This molten mixture is called matte.

It is withdrawn from the lower hole. It contains about 45% of copper.

$$2Cu_2S_{(l)} + 3O_{2(g)} \longrightarrow 2\,Cu_2O_{(s)} + 2SO_{2(g)} \uparrow$$

$$Cu_2O_{(l)} + FeS_{(l)} \longrightarrow Cu_2S_{(l)} + FeO_{(l)}$$

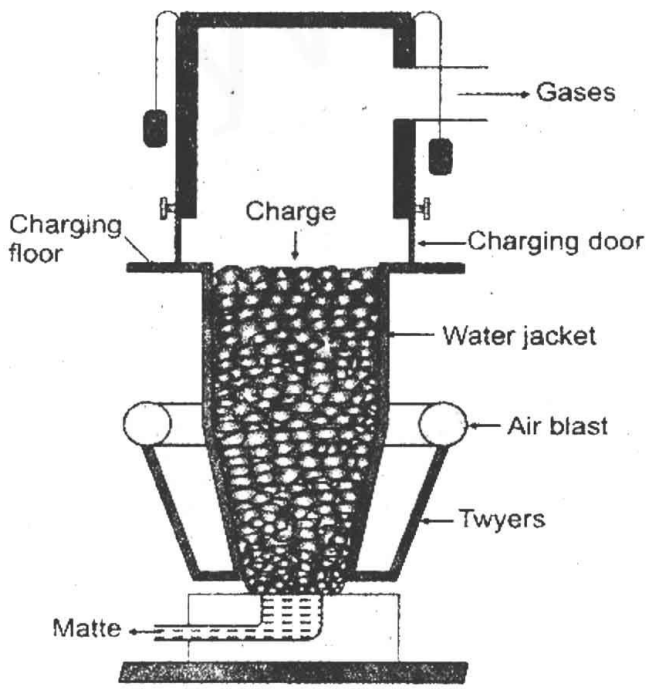


Fig: Blast furnace for smelting of copper

Bassemerization

It is the further heating of the molten matte in a pear shaped Bessemer converter as shown in figure. It is fixed on a pivot, so that it can be tilted in any direction. Molten matte is mixed

with sand and heated with a hot blast of air through tuyers. Ferrous sulphide is oxidized to form ferrous oxide. Which reacts with sand to form slag ($FeSiO_3$) that float on the top.

$$2FeS_{(l)} + 3O_{2(g)} \longrightarrow 2FeO_{(l)} + 2SO_{2(g)}$$

$$FeO_{(l)} + SiO_{2(s)} \longrightarrow Fe\,SiO_{3(slag)}$$

On the other hand, cuprous sulphide is oxidized to form cuprous oxide, which again reacts with remaining cuprous sulphide to form metallic copper.

$$2Cu_2S_{(l)} + 3O_{2(g)} \longrightarrow 2\,Cu_2O_{(l)} + 2SO_{2(g)} \uparrow$$

$$2Cu_2O_{(l)} + Cu_2S_{(l)} \longrightarrow 6Cu_{(s)} + SO_{2(g)} \uparrow$$

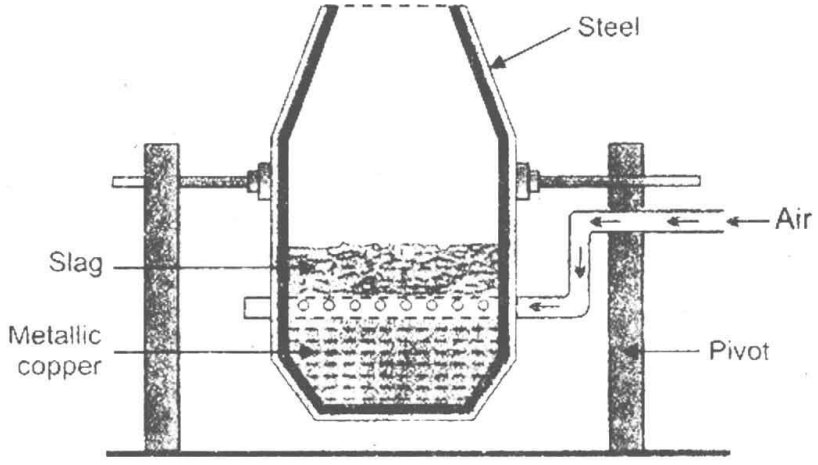


Fig: Bessemer Converter used for Bessemerization of copper

The molten metal is shifted from the converter to sand moulds and is allowed to cool. The dissolved gases escape out forming blisters on the surface of the solid copper therefore it is called blister copper. It is about 98% pure copper. It is further refined by electrolysis.

Q.4 Explain the process of refining with reference to copper.

Ans. Refining or purification of the copper metal.

Refining the impure metal by electrolysis is the most widely used process of refining metals.

Example

Electrolytic refining of copper is carried out in an electrolytic tank having copper sulphate solution in it as shown in figure. Two electrodes; one of impure copper metal that acts as anode and the other of pure copper metal that acts as cathode are suspended in the electrolytic solution.

On passing the electric current through the solution, anode (impure copper) dissolves to provide Cu^{2+} ions to the solution. These Cu^{2+} ions are discharged by gaining of electrons from the cathode. Thereby copper atoms deposit on the cathode, making it thick block of pure copper metal as is shown in figure. The impurities like gold and silver settle down as anode mud.

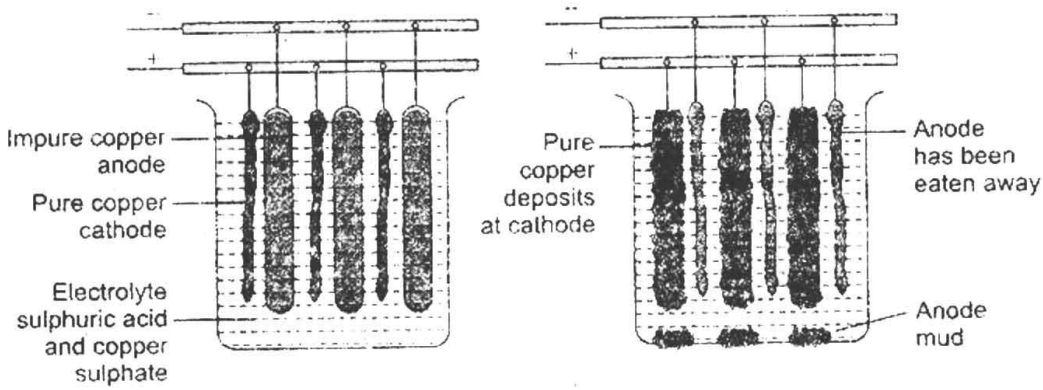


Fig: Electro refining of copper

In the process, impure copper from the anode dissolves and goes into the copper sulphate solution. Side by side, pure copper ions from the solution deposit on the cathode. Thus, cathode becomes a pure copper metal. The impurities like gold and silver settle down as anode mud.

Q.5 Write detail note on ammonia Solvay process.

Ans. Principle of ammonia solvay's process

Principle of Solvay's process lies in the low solubility of sodium bicarbonate at low temperature i.e. at 15°C. When CO_2 is passed through an ammonical solution of NaCl called ammonical brine only $NaHCO_3$ precipitates.

$$Na^+_{(aq)} + HCO_3^-{}_{(aq)} \longrightarrow NaHCO_{3(s)}$$

Raw Materials

The raw materials needed for this process are cheap and easily available. They are in abundance, such as,

i. Sodium chloride (NaCl) or brine. ii. Limestone ($CaCO_3$)

iii. Ammonia gas (NH_3)

Basic Reactions

The process consists of the following steps:

i. Preparation of ammonical brine

First of all ammonical brine is prepared by dissolving ammonia gas in sodium chloride solution (brine).

ii. Carbonation of ammonical brine

Ammonical brine is fed into carbonating tower and carbon dioxide is passed through it. Following reactions take place in the carbonating tower.

$$CO_{2(g)} + NH_{3(g)} + H_2O_{(l)} \longrightarrow NH_4HCO_{3(aq)}$$

$$NH_4HCO_{3(aq)} + NaCl\ (brine) \longrightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$$

The temperature of the mixture is lowered to 15^0C and precipitates of $NaHCO_3$ are obtained.

iii. Filtration of precipitates

The milky solution from the carbonating tower is filtered to get sodium bicarbonate. It is used as a baking soda.

iv. Calcinations

Sodium bicarbonate is heated to get sodium carbonate.

$$2NaHCO_{3(1)} \xrightarrow{\Delta} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(1)}$$

CO_2 is again used in tower. It is about half of CO_2 needed in the process.

v. Preparation of carbon dioxide and slaked lime

CO_2 is prepared by heating limestone in a lime kiln. Then it is carried to carbonating tower

$$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$$

Quick lime (CaO) formed in lime kiln is slaked with water. Then, it is pumped to the ammonia recovery tower.

$$CaO(g) + H_2O_{(1)} \xrightarrow{\Delta} \underset{\text{(Slaked lime)}}{Ca(OH)_2}$$

vi. Ammonia recovery tower

Ammonia is recovered in this tower from ammonium chloride solution produced in the carbonated tower and calcium hydroxide formed in lime kiln.

$$2NH_4Cl_{(s)} + Ca(OH)_{2(1)} \longrightarrow 2NH_{3(s)} + CaCl_{2(s)} + 2H_2O_{(1)}$$

In fact, all ammonia is recovered in this tower and is reused in the process. There are minor losses of ammonia in the process which are compensated by using fresh ammonia.

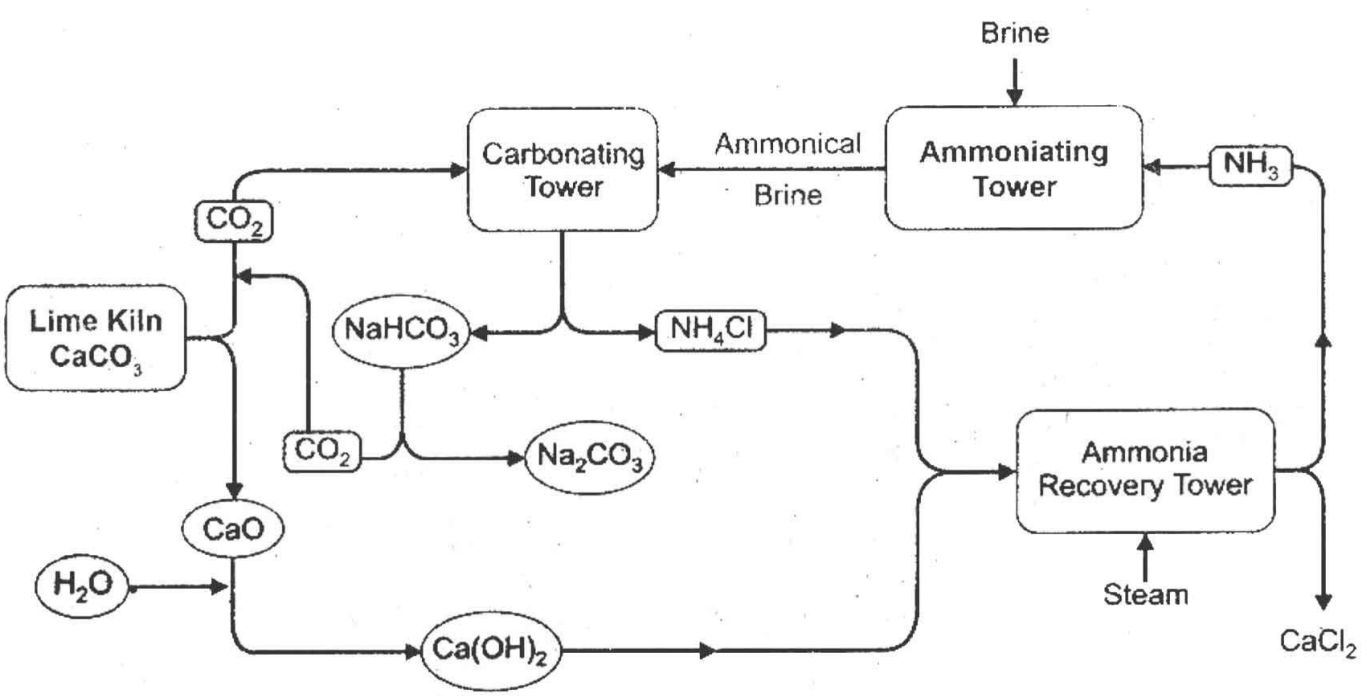


Fig: Flow sheet diagram of Solvay's process for the manufacturing of sodium carbonate

Q.6 Write down advantages of Solvay's process.

Ans. Advantages of Solvay's process

Following are the advantages of Solvay's process

i. It is a cheap process as raw materials are available at very low prices.
ii. Carbon dioxide and ammonia are recovered and reused.
iii. Process is pollution free, because the only waste is calcium chloride solution.
iv. Sodium carbonate of very high purity is obtained.
v. Consumption of fuel is very less since no solution is to be evaporated.

Q.7 How urea is manufactured. Explain showing the flow sheet diagram?

Ans. Manufactured of Urea

Urea is nitrogenous fertilizer. It consists of 46.6% nitrogen. It is white crystalline compound, highly soluble in water. It is used for the manufacturing of important chemicals, but its major (about 90%) use is as a fertilizer.

Raw Material

The raw materials for the manufacturing of urea are:

(i) Ammonia (NH_3) **(ii)** Carbon dioxide (CO_2)

Preparation of Ammonia by Haber's process

Ammonia is prepared by the "Haber's process". One volume of nitrogen (from air and three volumes of hydrogen (obtained by passing methane and steam over nickel catalyst) is passed over iron catalyst at 450°C and 200 atm pressure.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow[200\,atm]{450^\circ C} 2NH_{3(g)}$$

Process

Manufacturing of urea involves three stages

i. Reaction of ammonia and carbon dioxide

Carbon dioxide is passed through liquid ammonia under high pressure to form **ammonium carbamate**

$$2NH_3 + CO_2 \xrightarrow{\Delta} \underset{\text{Ammonium carbonate}}{NH_2COONH_4}$$

ii. Urea formation:

When ammonium carbamate is evaporated with the help of steam, it dehydrates to form urea.

$$NH_2COONH_4 \longrightarrow \underset{\text{(Urea)}}{NH_2CONH_2} + H_2O \uparrow$$

iii. Granulation of urea

At this stage, liquid urea is evaporated to form granules. When liquid urea is sprayed from top of a tower under pressure and a hot current of air is introduced from the base, it evaporates to form granules. This is stored to be marketed.

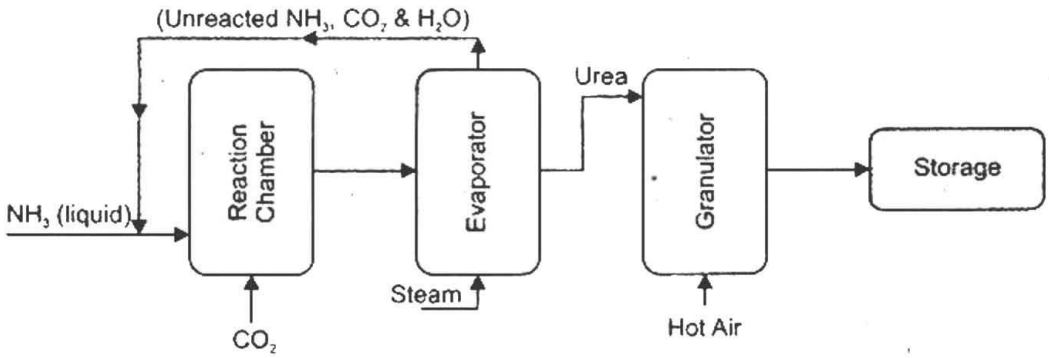


Fig: Flow sheet diagram of urea

Q.8 Explain importance and status of urea.

Ans. Importance and Status of Urea

It is white crystalline organic compound. Its importance is because of following usage:

i. Urea is widely used world over in the agriculture sector both as a fertilizer and animal feed additive. About 90% of urea is used as fertilizer. It has the highest nitrogen percentage, i.e. much higher than other nitrogenous fertilizers. It is harmless and is useful for all types of crops and soils.

It is non-toxic, non-explosive, therefore, can be stored safely. But it is very soluble in water and hygroscopic, therefore, storage requires better packing.

ii. It is used as a raw material for the manufacture of many important compounds.

iii. It is used to make explosives.

iv. It is used in automobile systems to reduce the NO_x pollutants in exhaust gases.

There are about six urea manufacturing units in Pakistan. The major four are Fauji Fertilizer company; Engro Chemicals; Faugji Fertilizer, Bin Qasim and Dawood Hercules company. Fauji Fertilizer is the biggest fertilizer manufacturer with 59% market shares.

Government provides an indirect subsidy to manufacturers but this industry is still facing supply shortfall problems. The price of urea has grown since the last years.

Q.9 Define Petroleum explain the origin of petroleum in detail.

Ans.

1. Petroleum

Petroleum is a natural product found under the Earth's crust trapped in rocks. Petroleum means rock oil. It is a complex mixture of several gaseous, liquid and solid hydro carbon

having water, salts and earth particles with it. It is lighter than water is insoluble in it.

2. Origin of Petroleum

Petroleum was formed by the decomposition of dead plants and animals buried under earth's crust millions of years ago. It is believed that millions of years ago living plants and animals in the sea died. Their bodies sank and buried under mud and sand. Then decomposition process took place in the absence of air because of high pressure, temperature and bacterial effects. This process took millions of years for completion. Thus, remains of dead plants and animals were converted into a dark brownish viscous **crude oil**. It was trapped between two layes of impervious rocks. As shown in figure

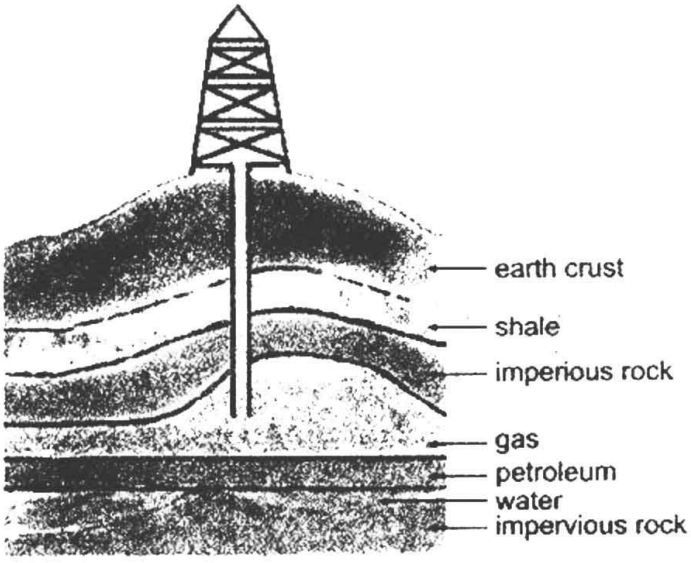


Fig: Occurrence of petroleum

Being lighter and insoluble in water it floats over the water and forms an oil trap. The gaseous products accumulated over the petroleum are found as natural gas.

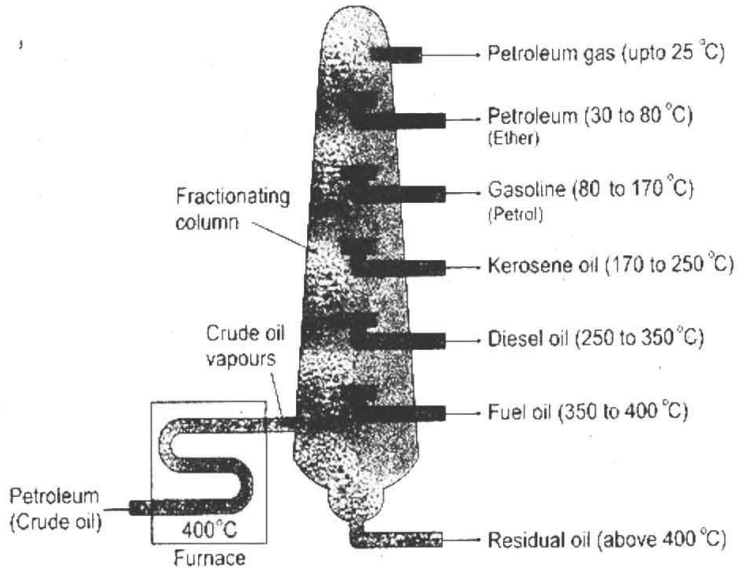
Petroleum is extracted by drilling holes (oil wells) into Earth's crust where the oil is found. When a well is drilled through the rocks, natural gas comes first with a great pressure. For some time crude oil also comes out by itself due to gas pressure. When gas pressure subsides, then crude oil is pumped out.

Q.10 Write a note on fractional distillation of petroleum.

Ans. Refining

The crude oil is refined in the refineries. **Refining** process is the separation of crude oil mixture into various useful products (fractions). It is carried out by a process called **fractional distillation**. The principle of fractional distillation is based upon separation of substances depending upon their boiling points. The substances having low boiling point out first, living behind others. The next fraction of having slightly higher boiling point boils out. This process remain continue until a residue is left behind. The vapours of each fraction are collected and condensed separately.

The crude oil is heated in a furnace upto a temperature of 400°C under high pressure. Then vapours are passed through a fractionating column from near its bottom as shown in figure. Hot vapours rise up in the column and gradually is cools down and condense. Such that vapours of higher boiling point fraction (350°C to 400°C) condense first in the lower part of the tower, while vapours of medium lower boiling point fractions rise upwards in the tower and condense gradually respect to their boiling points at different levels. In this way, crude oil is separated in to six hydrocarbon fractions. Each fraction has its specific boiling range, composition and uses.



Q.11 Describe some important fractions of petroleum and their uses.

Ans. Important fractions of petroleum and their uses

Each fraction is not a single compound. Each one is a mixture of hydrocarbons having different number of carbon atoms in it. The name of each fraction, its molecular composition, boiling range and uses are given in the following table.

Name	Composition	Boiling range	Uses
Petroleum Gas	C_1 to C_4	Up to 25°C	As a fuel, as such in the form of LPG, used for the production of carbon black (needed in tyre industry) and hydrogen gas (needed to form NH_3 used to manufacture fertilizer)
Petroleum Ether	C_5 to C_7	30 to 80°C	Used as laboratory solvent and for dry cleaning purposes.
Gasoline or Petrol	C_7 to C_{10}	80 to 170°C	Used as fuel in motor cycles, motor cars and other light vehicles. It is more volatile than kerosene oil. It is also used for dry cleaning.
Kerosene oil	C_{10} to C_{12}	170 to 250°C	Used as domestic fuel, a special grade of it is sued as jet fuel.

Diesel oil	C_{13} to C_{15}	250 to 350°C	Fuel for buses, trucks railway engines, tubewell engines and other heavy vehicles.
Fuel oil	C_{15} to C_{18}	350 to 400°C	Used in ships and industries to heat boilers and furnaces.

Residual Oil

The residual oil, which does not vapourize under these conditions is collected and heated above 400°C for further fractional distillation. The four fractions of residual oil are:

lubricants; paraffin wax; asphalt and petroleum coke.

Q.12 Explain that natural fertilizers are better than synthetic fertilizers.

Ans. Fertilizer is a substance added to soil to improve plants' growth and yield.

Natural Fertilizers

Contain all nautral biodegradable materials are decomposed by bacteria. Decomposed materials contain useful nutrient for plants. Organic matter is essential part of fertile soil. Use of natural fertilizers return the nutrients and organic matter of soil

They improve the soil condition to support plant growth.

i. They improve the porosity of the soil to make it capable of absorbing water. Thus improves crops production.

ii. They improve the structure of soil which in turn allows more air to get to plant roots.

iii. The chance of water shortage because of the moisture holding capacity of soil increases.

iv. Natural fertilizers practically do not contain toxic chemicals. Thus, they do not damage the soil and crops yield increase.

Chemical Fertilizers

Include one or more of the three elements most important for plant nutrition; nitrogen, phosphorus and potassium.

i. They release the nutrients very fastly.

ii. Their effects are short lived, so they are required again and again, after short intervals may be 4 to 6 times in a year.

iii. Use of synthetic fertilizers may cause over fertilization resulting in burning of plants instead of greening them.