CHAPTER

16 Chemical Industries

Animation 16.1: Jaw Crushing
Source & Credit: ZDZK

Students Learning Outcomes

Students will be able to:

- Describe some metallurgical operations. (Applying);
- Make a list of raw materials for Solvay process. (Applying);
- Outline the basic reactions of Solvay process. (Analyzing);
- Develop a flow sheet diagram of Solvay process. (Creating);
- Describe the composition of urea. (Understanding);
- Develop a flow sheet diagram for the manufacture of urea. (Creating);
- List the uses of urea. (Remembering);
- Define petroleum. (Remembering);
- Describe the formation of petroleum and natural gas. (Understanding);
- Describe the composition of petroleum. (Remembering) ;
- Describe briefly the fractional distillation of petroleum. (Applying).

Introduction

Chemical industries are established to meet the needs of modern societies. Metallurgy is the science of extracting metals from ores. Metals have played a major role in progress of societies. Since ages metals are used for making tools, machines and other items. In the modern age, although polymers have taken the place of metals, yet the importance of metals cannot be ignored.

Baking soda ($NaHCO_3$) and washing soda (Na_2CO_3) are used in daily life for different purposes. Solvay's process for the manufacturing of baking and washing soda from common salt will be discussed in detail.

Fertilizers are vital for the growth and development of plants and crops. One of the important fertilizers urea, is used to enhance the productivity of crops. Hence, the synthesis of urea has been explained here.

In the modern age of communication, petroleum industry has a great significance. Petroleum products are used as fuel, solvent and lubricants. Petrochemicals are used to manufacture a variety of household items, plastics, detergents, rubber,etc.

Pakistan industrial base was very weak at the time of independence. At the time of partition, there were 921 big industrial units in India, out of these only 34 came to the share of Pakistan. After the independence, government made a lot of policies and encouraged the private sector to establish industrial units. Chemical industry was rapidly developed because the chemicals are used for the manufacturing of ammunitions, fertilizers and other substances of daily use.

Animation 16.2: Mining
Source & Credit: wikia

A lot of steps and measures are taken to set up corporations to facilitate loans and technical know-how for the rapid development of industries. Pakistan is now producing chemicals, fertilizers, cement, steel, heavy engineering machines and tools.

16.1 BASIC METALLURGICAL OPERATIONS

First of all lets know definitions of terms used in metallurgical operations.

Minerals

The solid natural materials found beneath the Earth's surface, which contains compounds of metals in the combined state along with earthly impurities, are called minerals.

Ores

Those minerals from which the metals are extracted commercially at a comparatively low cost with minimum effort are called ores of the metals. For example: ores of copper are; copper glance (Cu_2S) and chalcopyrite ($CuFeS_2$). Hence, all ores of the metals are minerals, but all minerals are not ores.

Interesting Information

The colour of hair is caused by the presence of transition metal compounds in the hair. Brown hair contains iron or copper compounds, blonde hair contains compounds of titanium and redhead hair is because of the presence of molybdenum compounds.

Gangue

The earthly and other impurities associated with the minerals are known as gangue.

Metallurgy

The process of extraction of a metal in a pure state on a large scale from its ore by physical or chemical means is called metallurgy.

The processes involved in metallurgy for extraction of a metal in the pure state from its ore are:

(i) concentration of the ore;
(ii) extraction of the metal, and
(iii) refining of the metal.

(i) 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 16.1.

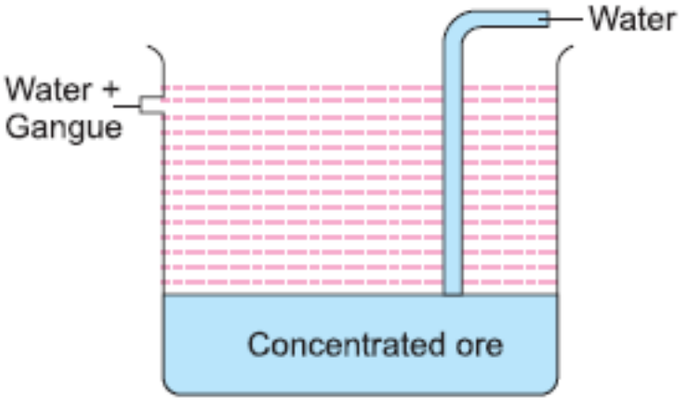


Fig. 16.1 Gravity separation

(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 water. The whole mixture is agitated with compressed air. Hence, oil coated ore particles being lighter come to the surface in the form of froth that can be skimmed as shown in figure 16.2.

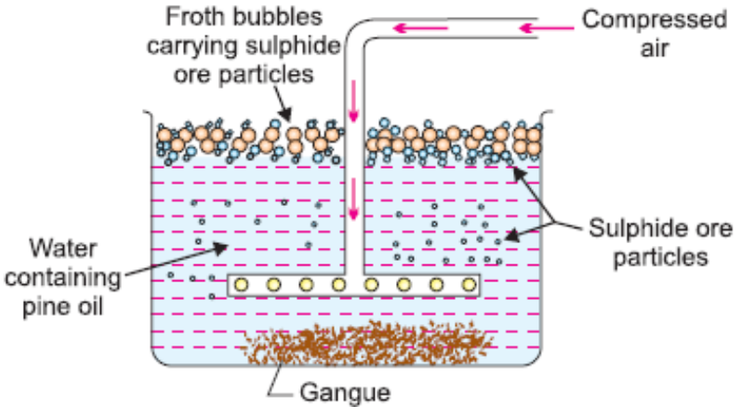


Fig. 16.2 Froth flotation process

(c) Electromagnetic separation

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

The powdered ore is dropped over a leather belt moving over two rollers, one of which is magnetic. The non-magnetic ore falls first and the magnetic ore gets attracted and falls farther away as shown in figure 16.3.

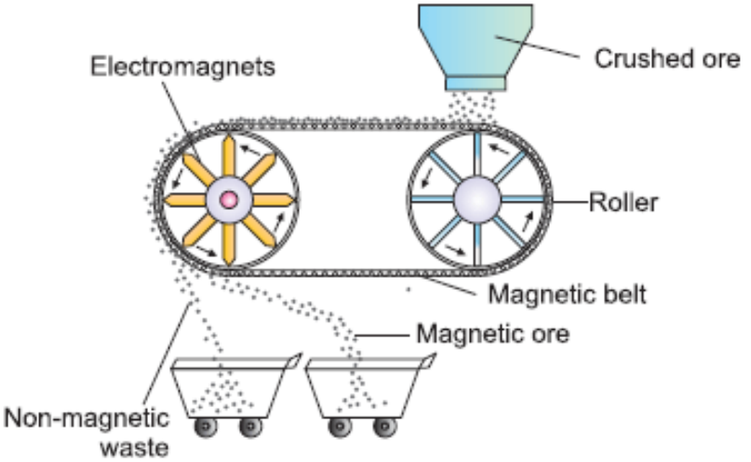


Fig 16.3: Magnetic separation

(ii) Extraction of the metal from the concentrated ore

The metal is isolated from the concentrated ore by chemical reduction or electrolytic processes. Chemical methods of reduction of ore involve following methods:

(a) Roasting: It is a process of heating the concentrated ore to a high temperature in excess of air. For 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 2 volatile oxides. Such as

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

(b) Smelting: It is further heating of the roasted ore with sand flux and coke in the presence of excess of air in a blast furnace as shown in figure 16.4. It is highly exothermic process, therefore, a small amount of coke is required in the process. In the process, first ferrous sulphide oxidizes to form ferrous oxide which reacts with sand to form iron silicate slag ($FeSiO_3$). It being lighter, rises to the top and is removed from the upper hole.

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

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

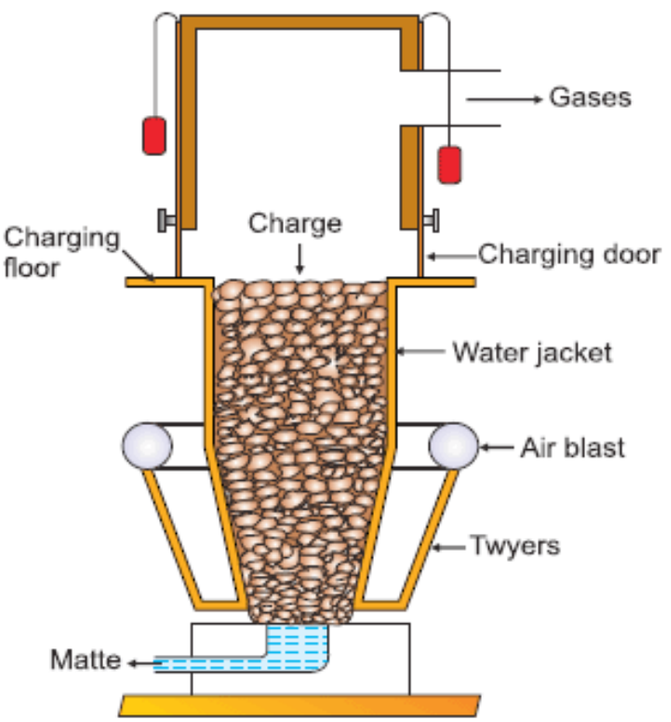


Fig. 16.4 Blast furnace for smelting of copper

On the other hand, cuprous sulphide also oxidizes to form cuprous oxide which reacts with unreacted 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.

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

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

(c) Bassemerization:

It is the further heating of the molten matte in a pear shaped bessemer converter as shown in figure 16.5. 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 twyers. Ferrous sulphide is oxidized to form ferrous oxide. Which reacts with sand to form slag ($FeSiO_3$) that floats on the top.

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

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

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

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

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

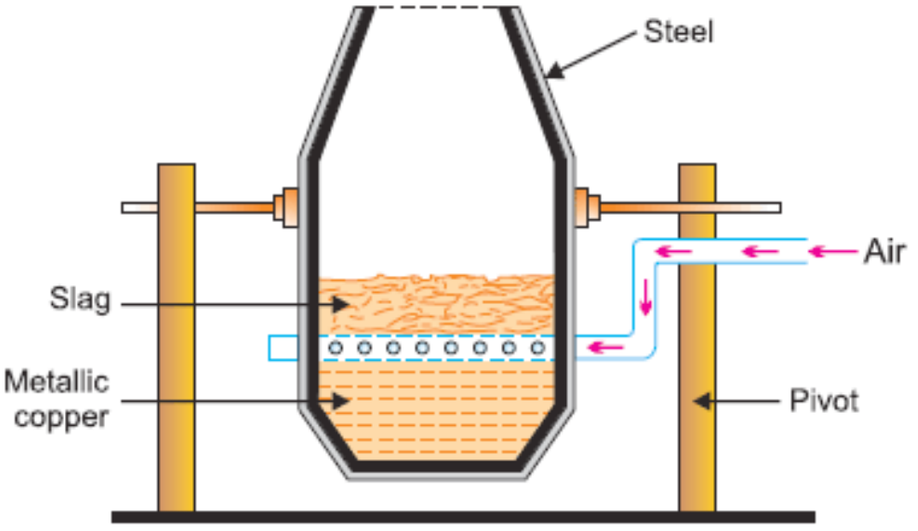


Fig. 16.5 Bessemer converter used for bessemerization of copper.

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.

(iii) Refining or purification of the metal

Refining the impure metal by electrolysis is the most widely used process of refining metals. For example, electrolytic refining of copper is carried out in an electrolytic tank having copper sulphate solution in it as shown in figure 16.6. 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 16.6. The impurities like gold and silver settle down as anode mud.

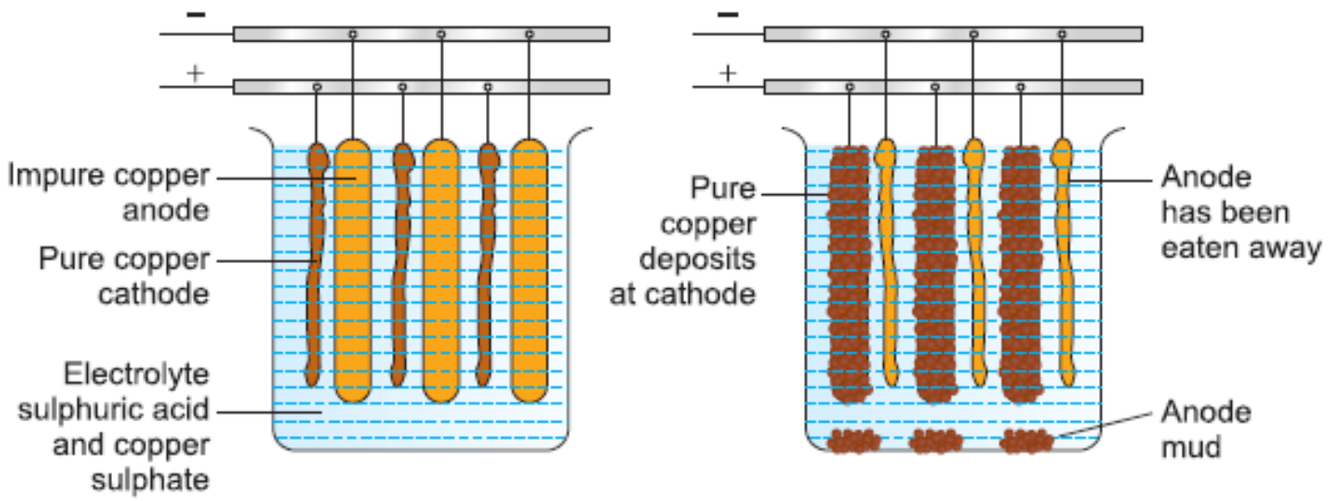


Fig. 16.6 Electrorefining of copper.

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.

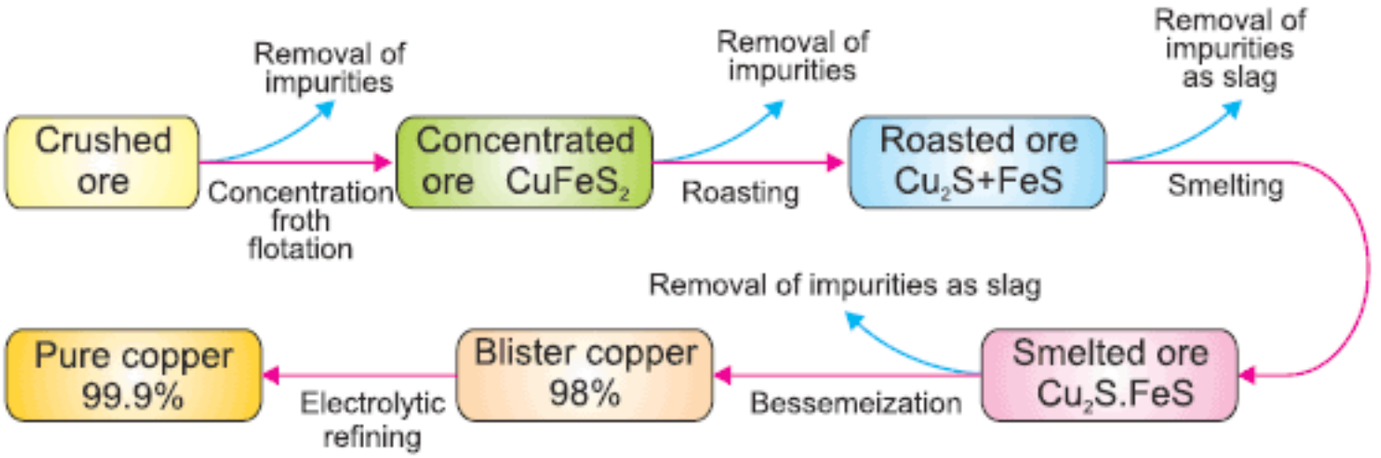


Fig. 16.7 Flow sheet diagram for extraction of copper

Test yourself 16.1

i. Define concentration process used in metallurgy of copper.
ii. Why a small amount of coke is required in the smelting process? How is slag formed during smelting.
iii. Why is lime added in the smelting process?
iv. How are slag and matte removed from the blast furnace?
v. What is difference between slag and matte?
vi. Mention the chemical reactions for the formation of metallic copper in the bessemerization process.
vii. What is blister copper?
viii. Why anode is eaten up in electrorefining process?
iv. What do you mean by anode mud?

16.2 MANUFACTURE OF SODIUM CARBONATE BY 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 $NaHCO_{3(s)}$ precipitates.

$$Na_2 \text{ zeolite} + CaSO_{4(aq)} \longrightarrow \text{Ca zeolite} + Na_2SO_{4(aq)}$$

16.2.1 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.

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

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

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

(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) Calcination:

Sodium bicarbonate is heated to get sodium carbonate.

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

CO_2 is again used in tower. It is about half of CO2 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

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

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

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow \underset{\text{(slaked lime)}}{Ca(OH)_2}$$

(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.

$$2NH_4Cl_{(aq)} + Ca(OH)_{2\,(aq)} \longrightarrow 2NH_{3(g)} + CaCl_{2(aq)} + 2H_2O_{(l)}$$

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 some fresh ammonia.

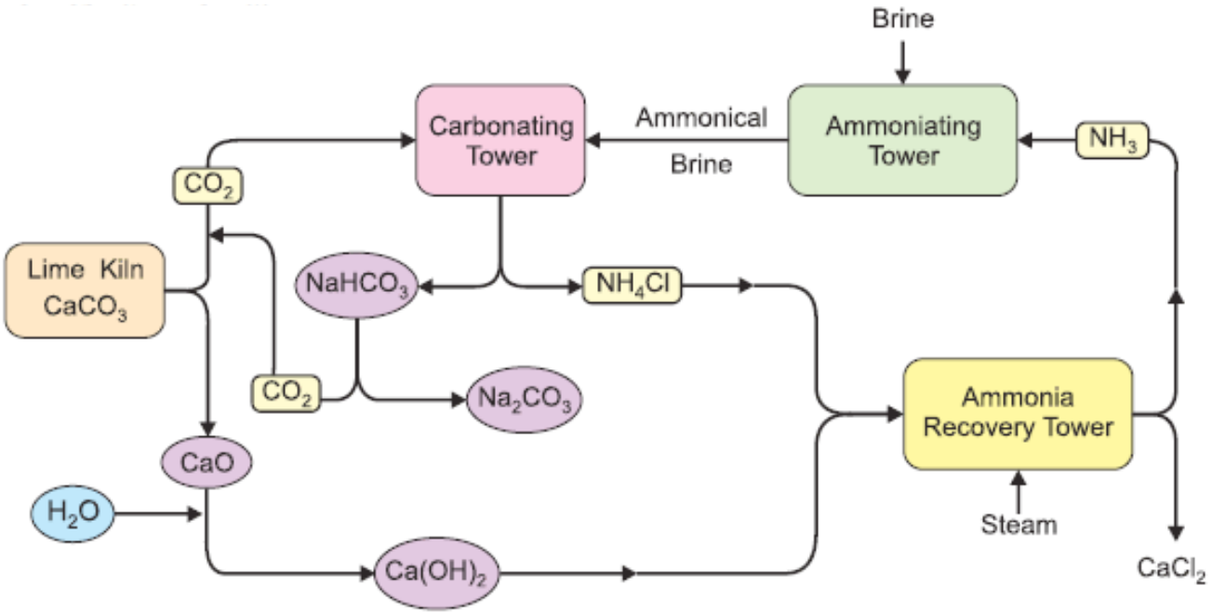


Fig. 16.8: Flow sheet diagram of Solvay's Process for the manufacturing of sodium carbonate.

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.

Pakistan is self-sufficient as far as demand of sodium carbonate is concerned. Imperial Chemical Industries (ICI) Khewra (Jhelum) is producing enough sodium carbonate. This unit was established in 1944 in Khewra because abundant raw material sodium chloride is available here. Sindh alkalies limited was established near Karachi in 1966. Sodium carbonate and sodium bicarbonate are important industrial chemicals and are used by many industries.

Test yourself 16.2

i. Why only $NaHCO_3$ precipitates, when CO_2 is passed through the ammonical brine?
ii. Which raw materials are required for the formation of sodium carbonate?
iii. How is CO_2 prepared in the Solvay's process?
iv. Give the reaction of formation of ammonia in the process.
v. Give the advantages of Solvay's process.

Role of technology in the production of common chemicals.

Technology is considered a consequence of science and engineering.Common chemicals such as acids, alkalies, salts, soaps, detergents, etc. are being produced on commercial scale by chemists or chemical engineers since centuries. Technology began to influence human efforts to produce common chemicals since people began using different tools and machineries.

Now it is because of use of technology that needs of people are being fulfilled. Use of technology has increased the production with improved quality of products.

16.3 Manufacture 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.

16.3.1 Raw Materials

The raw materials for the manufacturing of urea are:

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

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 heated nickel catalyst) is passed over iron catalyst at 450°C and 200 atm pressure.

$$N_{2(g)} + 3H_{2(g)} \underset{200\ atm}{\overset{450°C}{\rightleftharpoons}} 2NH_{3(g)}$$

16.3.2 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.**

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

(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.

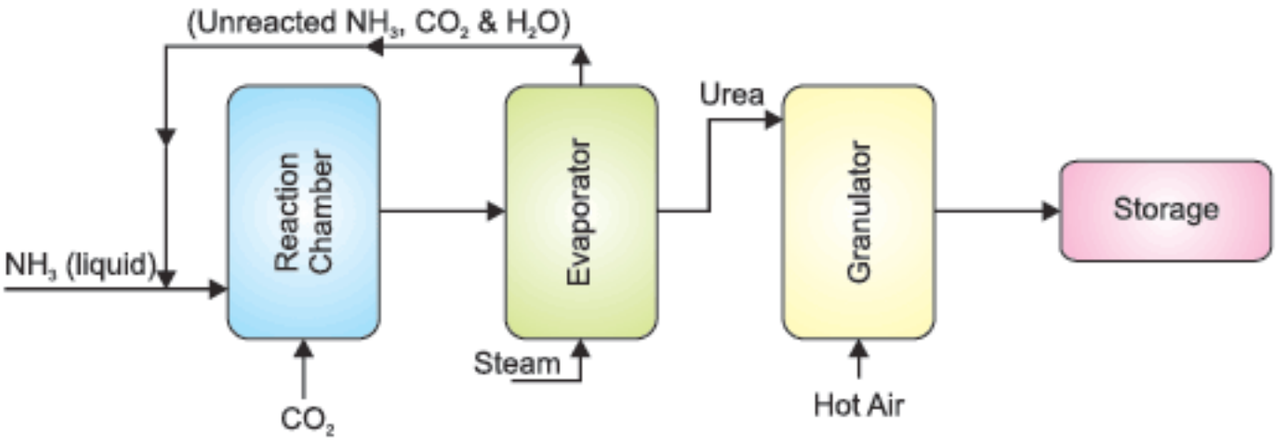


Fig. 16.9 Flow sheet diagram of Urea

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; Fauji 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 gears.

Test yourself 16.3

i. What happens when ammonium carbamate is heated with steam?
ii. How many stages are involved in the formation of urea?
iii. What is the percentage of nitrogen in urea?

Interesting information

Crops need phosphorus and nitrogen to grow well. Although, there is 78% nitrogen in air yet it can't be assimilated directly by plants. Therefore, fertilizers are used to provide these essential elements to soil and ultimately plants.

Natural Fertilizers are better than Synthetic Fertilizers.

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

Natural Fertilizers contain all natural biodegradable materials from livestock and human waste and foliage of plants. These materials are decomposed by bacteria Decomposed materials contain useful nutrient for plants. Organic matter is essential part of fertile soil. Uses of natural fertilizers return the nutrients and organic matter of soil.

- They improve the soil condition to support plant growth.
- They improve the porosity of the soil to make it capable of absorbing water. Thus improves crops production.
- They improve the structure of soil which in turn allows more air to get to plant roots.
- The chance of water shortage because of the moisture holding capacity of soil increases.
- 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.

- They release the nutrients very fastly.
- Their effects are short lived, so they are required again and again, after short intervals may be 4 to 6 times in a year.
- Use of synthetic fertilizers may cause over fertilization resulting in burning of plants instead of greening them.

16.4 PETROLEUM INDUSTRY

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

16.4.2 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 seas 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 layers of impervious rocks, as shown in figure 16.10.

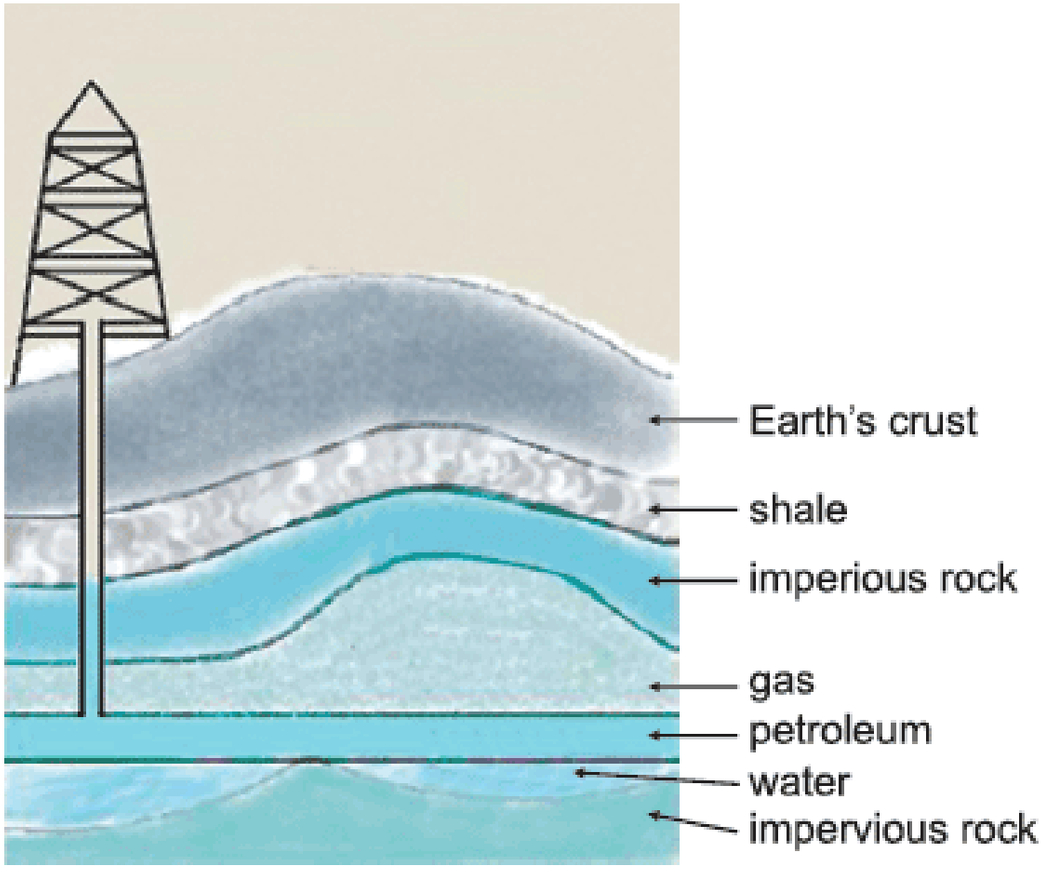


Fig. 16.10 Occurrence of petroleum

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.

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 points boil out first, leaving behind others. Then next fraction of 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 fractional distillation of petroleum is carried out in a tall fractionating tower as shown in figure 16.11

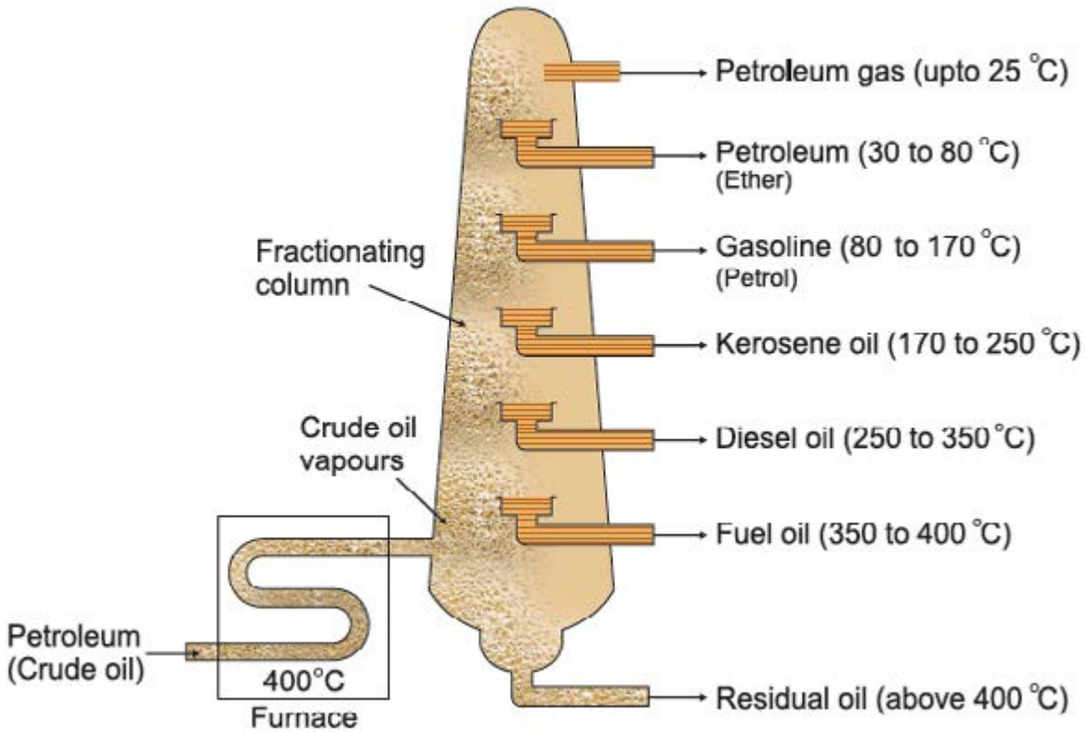


Fig 16.11 Fractional distillation of petroleum.

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 16.11. Hot vapours rise up in the column and gradually cool down and condense. Such that vapours of higher boiling point fraction (350—400°C) condense first in the lower part of the tower, while vapours of medium and lower boiling point fractions rise upwards in the tower and condense gradually with respect to their boiling points at different levels. In this way, crude oil is separated into six hydrocarbon fractions as discussed below. Each fraction has its specific boiling range, composition and uses.

16.4.3 Important Fractions of Petroleum

Each fraction is not a single compound. Rather 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 16.2:

Table 16.2 Fractions of Petroleum			
Name	Composition	Boiling range	Uses
Petroleum Gas	C_1 to C_4	up to 25^0 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 80^0 C	Used as laboratory solvent and for dry cleaning purposes.
Gasoline or Petrol	C_7 to C_{10}	80 to 170^0 C	Used as a 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 250^0 C	Used as domestic fuel, a special grade of it is used as jet fuel.
Diesel oil	C_{13} to C_{15}	250 to 350^0C	Fuel for buses, trucks railway engines, tubewell engines and other heavy vehicles.
Fuel oil	C_{15} to C_{18}	350 to 400^0 C	Used in ships and industries to heat boilers and furnaces.

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.

Interesting information

The diesel fuel sold in winter is different mixture of hydrocarbons from the mixture sold in summer. This is because diesel sets rather like Vaseline at a little below 0^0 C and will not work as a fuel. More of the lighter fractions are added in winter to prevent this.

i. Define petroleum.
ii. How petroleum is extracted?
iii. What is principle of fractional distillation?
iv. In how many fractions crude oil is separated?
v. What do you mean by a fraction of petroleum?

Different types of fire require different methods to extinguish.

The things needed to start and sustain fire are:

Fuel: The substance that burns in the combustion process, e.g. wood, oil and electricity.

Heat: The energy component of the fire when it comes in contact with fuel, it provides the energy necessary for ignition and sustaining combustion process.

Air(oxygen): it is essential component for combustion process.

A self-sustained chemical chain reaction is a complex reaction that requires fuel, oxygen and heat energy to come together in a very specific way.

Fire can be put out by taking away any of the above-mentioned components. When fuels are different, they require different techniques to put them out.

Wood fire can be extinguished by throwing water on it. Water uses large amount of heat for evaporation process, so it absorbs huge amount of heat and deprives the wood fire of heat and it is not possible for fire to be sustained.

Oil fires can't be put out with water because oil and water do not mix. Oil being lighter than water, floats and spreads over it. The fire also spreads along with water. To put out oil fire, oxygen needs to be cut off. This can be controlled by throwing sand, table salt or baking soda on the flames.

Electric fire is much stronger than other fires because its source of heat is electrical energy. It requires cut off oxygen supply to put it out. Oxygen supply can be controlled by using fire extinguishers.

Chemistry as a career in industry.

By studying chemistry one can be a professional chemist. He studies the composition and properties of available chemicals. Then he develops methods to manufacture new substances on commercial scale to meet the needs of society. He also designs and develops instruments and techniques to make the production more and more economical.

Chemists can have working opportunities in almost all fields of industry depending upon their areas of specialization.

Organic chemists have career in pharmaceutical, petroleum, petrochemicals, cosmetic, polymer and plastic
industries.

Inorganic chemists work in metallurgical industries; manufacturing industries like textile, cement, sugar and chemicals; manufacturing plants like fertilizer, acids and caustic soda.

Physical chemists have working opportunities in energy transformation industries. They develop new and better energy sources. They explore renewable energy fields. Analytical chemists work in almost all fields of industry. They identify the materials, measure their quantities and control the quality of the products. They evaluate the efficiency and devise techniques to enhance the production. They have working scope from food and beverage
industry to paints and varnish industry. They work even in generating units. Besides these major career opportunities there are many other types of chemists such as biochemists, food chemists, material chemists, etc.

Good communication skills promote the sale.

Communication is the exchange of information to others through audio, video, print or electronic media.

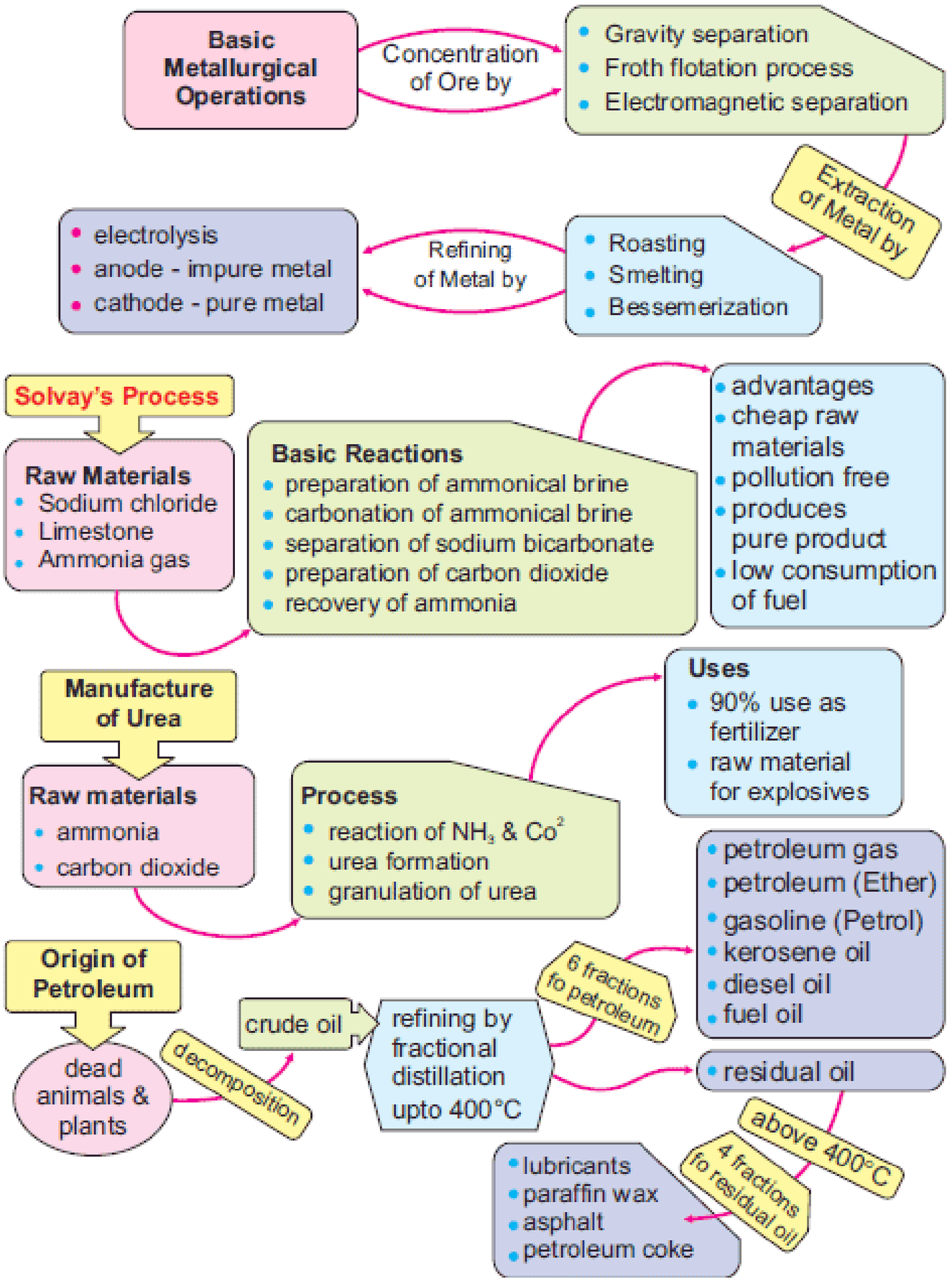
Good communication skills help ensure the efficient operation of all levels of an organization, from lowest to highest, whereas poor communication skills often result In inefficiency. Successful business leaders know, inefficiency equals a loss of productivity and consequently, a loss of profits.

Moreover, communication can make the difference between success and failure for a company. Therefore, in the field of chemical industry good communication skills are also vital.

Key Points

- Metallurgy is technique by which metals are extracted from their ores.
- Concentration is a separating technique in which mineral is separated from gangue.
- Sodium carbonate is manufactured by Solvay's process. The raw materials used in this process are sodium chloride, carbon dioxide and ammonia.
- Ammonical brine is prepared by dissolving ammonia gas in sodium chloride
- solution. When this solution is carbonated; first NH_4HCO_3 forms, which reacts with NaCl to form $NaHCO_3$.
- $NaHCO_3$ on heating produces Na_2CO
- Urea is manufactured from ammonia and carbon dioxide. First Ammonia and
- carbon dioxide react to form ammonium carbamate. On evaporation, it dehydrates to form urea.
- Petroleum is a complex mixture of hydrocarbons. It forms by the decomposition of dead animals and plants buried under the Earth's crust.
- Crude oil is pumped out and then refined in the refineries. Refining is carried out by fractional distillation on heating crude oil at 400°C.
- The important fractions of petroleum are; petroleum gas, petroleum ether, petrol, kerosene oil, diesel and fuel oil.
- The residual oil is heated above 400°C to produce lubricants, paraffin wax, asphalt and petroleum coke.

Concept Diagram



Short Questions

1. What role is played by pine oil in the froth flotation process?
2. Name the various metallurgical operations.
3. How is roasting carried out?
4. Explain process of electrorefining.
5. What are the advantages of Solvay's process?
6. What is the principle of Solvay's process?
7. What happens when ammonical brine is carbonated?
8. How $NaHCO_3$ is converted to Na_2CO_3 ?
9. How is ammonia recovered in the Solvay's process?
10. How is ammonia prepared for the synthesis of urea?
11. Describe the formation of petroleum.
12. What is refining of petroleum and how is it carried out?
13. Give a use of kerosene oil?
14. Describe the difference between diesel oil and fuel oil?
15. Write down the names of four fractions obtained by the fractional distillation of residual oil?
16. What is the difference between crude oil and residual oil?
17. Which petroleum fraction is used in dry cleaning?

Extensive Questions

1. Describe in detail the various processes involved in the concentration of ore. Explain your answer with the help of diagrams?
2. Explain the process of roasting with reference to copper?
3. Write a detailed note on Ammonia Solvay's process?
4. Write a note on fractional distillation of petroleum?
5. How urea is manufactured? Explain showing the flow sheet diagram?
6. How crude oil is refined? Explain two important fractions of petroleum along with their usage?
7. Write a note in detail on smelting and bessemerization, giving a specific example?