

	Unit	Teaching (Periods)	Assessment (Periods)	Weightage %
16	Chemical Industries	13	3	18

Introduction

The rapidly growing population and the desire to raise the standard of living has forced the scientists to devise methods for preparing cheaper substitutes of substances obtained from natural sources. For this purpose, they developed new methods of preparation at low cost, large scale and improved quality. They established industries in order to meet the needs of modern society.

Thousands of products like fertilizers, detergents, plastics, synthetic fibers, glass pharmaceuticals, food products, paints, soaps etc and their applications have increased the standard of living of billions of people in the last few centuries. Chemical industries also play a vital role in the economic development of a country.

Have you ever thought of how we get petrol and diesel for running our vehicles? How metals are extracted from their ores? How baking and washing sodas and urea are manufactured commercially from cheap raw materials? How petrol etc are produced? After studying this unit, you will be able to answer these questions.

Real world reading link

The industries play an important role to convert low cost raw materials into useful and usable products. These include a large variety of products such as from soaps to fertilizers, from synthetic rubber to pharmaceuticals.

Petroleum products such as petrol and diesel are obtained from refining of crude oil in a refinery.

16.1 Basic Metallurgical Operations With Reference to Copper

The increasing use of metals in day-to-day life wake up the interest of man in their properties and the sources from which they could be recovered. This gave birth to a new branch in chemistry called **metallurgy**.

Metallurgy

The science that deals with the procedures used in extracting metals from their ores, purifying, alloying metals and creating useful objects from metals is called **metallurgy**. Metallurgy is also the practice of removing valuable metals from its ore and refining the extracted raw metals into a purest form. Most of the metals such as iron, copper, sodium etc.

are found in combined state in nature, which are called minerals. An aggregate of minerals and other impurities is known as ore.

Mineral

The majority of metals are usually found in combined form having definite chemical composition. The naturally occurring metallic compounds are called minerals.

Ores

An aggregate of mineral and other impurities is known as ore. A naturally occurring solid material from which a metal or valuable mineral can be extracted profitably is called an ore.

Gangue

The earthy materials such as sand, rock, clay and other impurities attached with the ores are called gangue.

Occurrence of metals

Metals occur in nature either in free state or in combined state. A metal is said to occur native or free when it is found in nature in the metallic state for example gold, silver, platinum etc. Mostly these unreactive metals are not affected by air and water. Whereas, the reactive metals like sodium, calcium, potassium etc. are chemically reactive or affected by air, water and other chemical reagents. Generally they occur in **combined state** with non-metallic elements for example PbS , ZnS , Fe_2O_3 , Al_2O_3 , CaF_2 etc.

Basic Metallurgical Operations

It involves many physical and chemical processes. In these processes, metal is not only separated from their respective ores but it is also made suitable for use, because most of the metals are not suitable for use in pure form.

There is no single method for extracting of all metals from their ores. Because metals exists in various forms in combined state such as oxides, sulphides, halides, carbonates, silicates, sulphates and phosphates etc. Metals are extracted from their ores by variety of methods. For example, reactive metals like sodium, potassium, calcium and aluminum etc. are extracted by electrochemical process while low reactive metals such as iron, copper, zinc and lead etc. are extracted by entirely chemical methods. The selection of the process for extraction is mainly depended upon the following factors.

- (a). Type of the ores i.e. oxide, sulphide, carbonate or halide etc.
- (b). Reactivity of the metal contained in the ores.
- (c). Nature of the gangue present in the ores.

An overview of various processes involved during metallurgy is given below in figure 16.1.

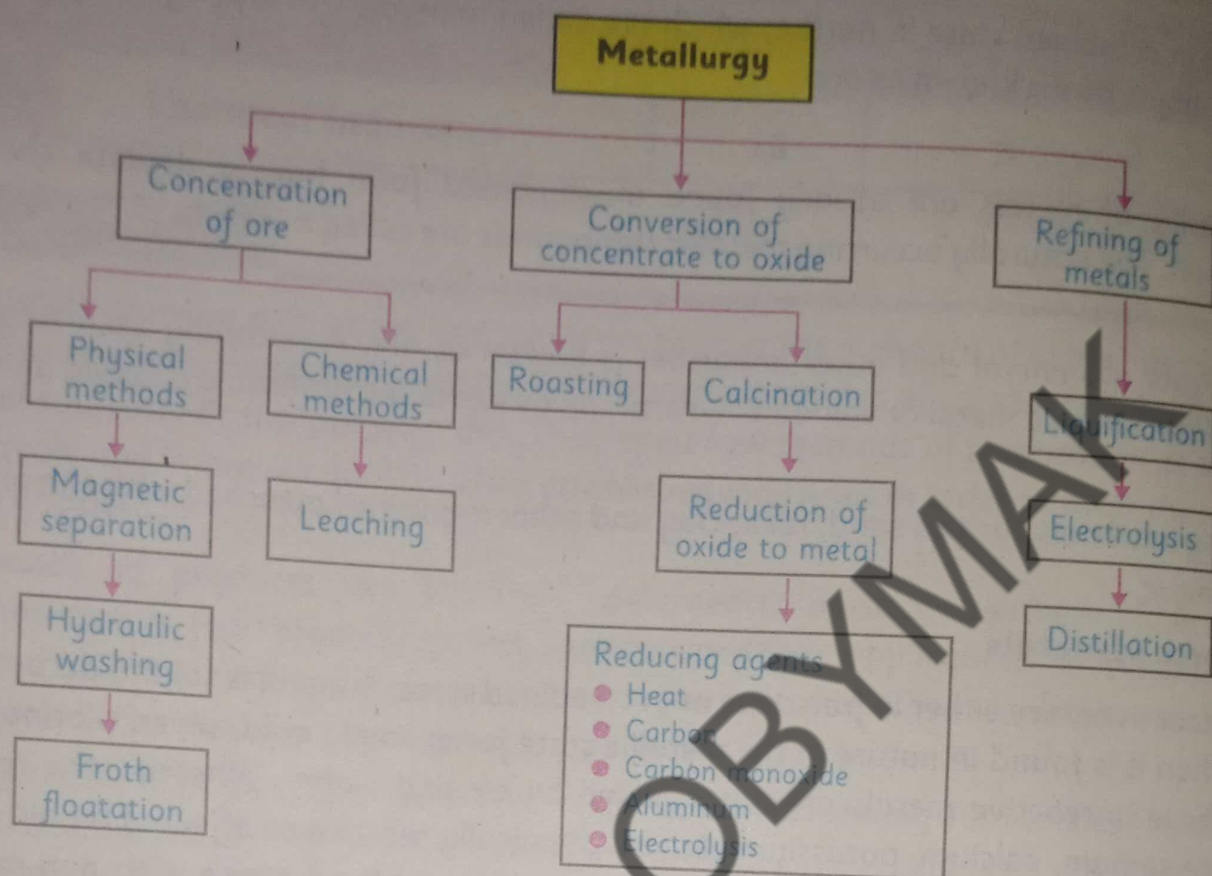


Fig.16.1 Metallurgy Processes

The steps involved in metallurgy for extraction of metals in the pure state from its ores are;

16.1.1 Concentration of Ore

The removal of useless rocky portion of the ore is called **concentration of ore**. This is also called as **Enrichment of ore or dressing of the ore**. Ore is an impure metal containing large amount of sand and rocky material. The impurities like sand, rocky materials, limestone, mica etc. are called gangue or matrix. These impurities must be removed from the ore before the extraction of metal, to avoid bulk handling and in subsequent fuel costs.

16.1.1.1 Crushing and grinding of the ore

Huge lumps of ores are broken into small pieces with the help of crushers or grinders. These pieces are then reduced to fine powder with the help of a **ball mill or stamp mill**. This process is called **pulverization**. Depending upon the nature of the ore, one or more of the following steps are taken to concentrate the ore. These are mostly physical methods of concentration and also some chemical methods.

1. Hand picking

In this method, the ores are concentrated to sufficient degree of purity by simply picking it with hand and breaking the rock stones with hammers.

2. Hydraulic Washing (Gravity separation)

This method is based on the difference in densities of the ore and gangue.

In this process, the ore particles are poured over a hydraulic classifier, which is a vibrating inclined table with grooves and a jet of water is allowed to flow over it. The denser ore settles in the grooves while the lighter gangue particles are washed away. The hydraulic washing method is shown in the following fig. 16.2.

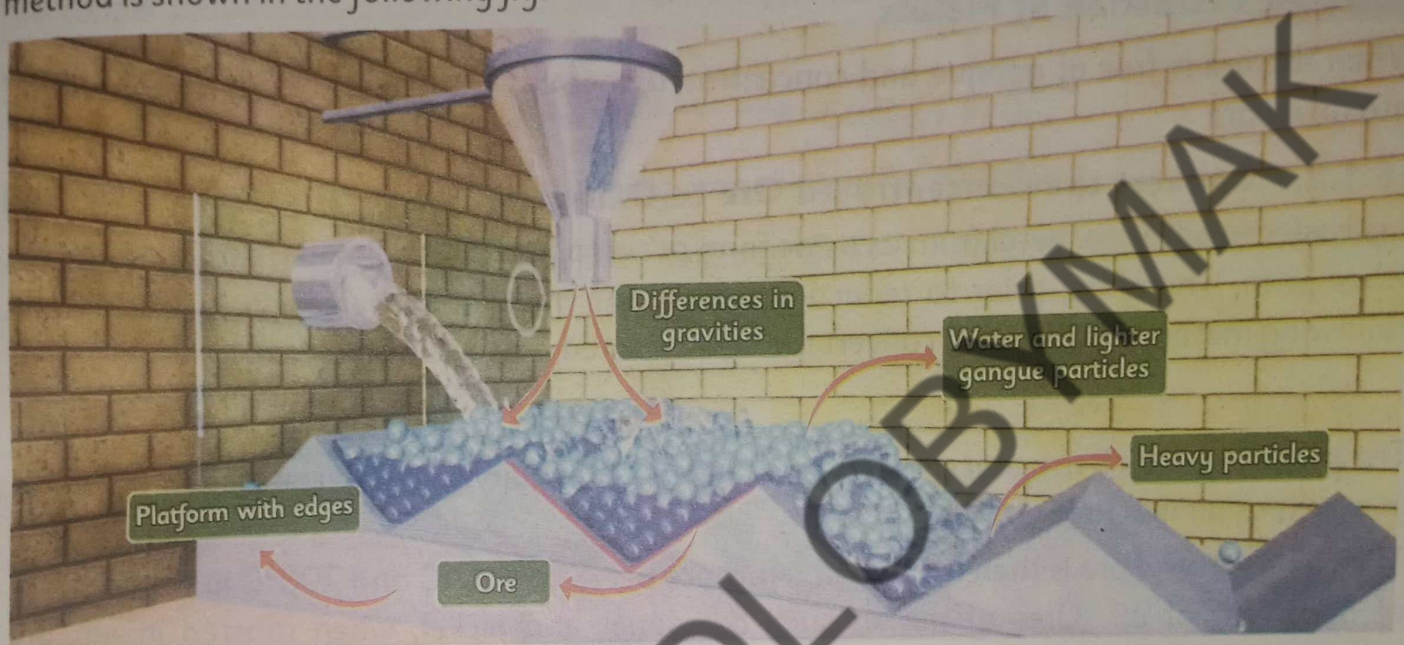


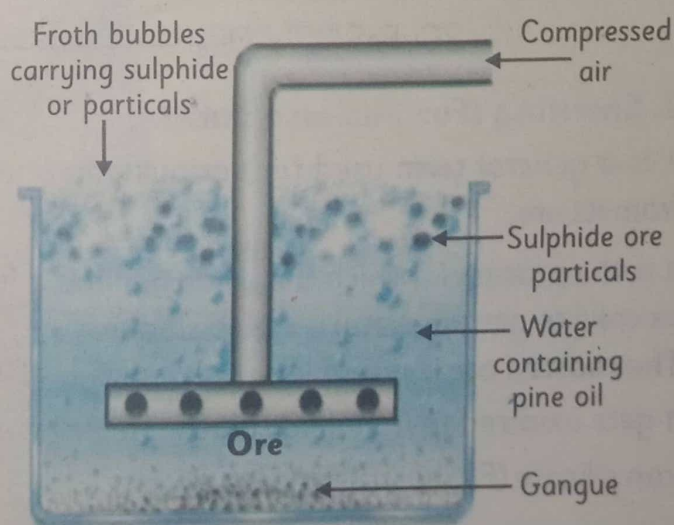
Fig.16.2 Hydraulic washing

3. Froth floatation

This method is based on the wetting of the ore and gangue with pine oil and water.

This method is especially used for sulphide ores. In this method a mixture of water, pine oil and detergents are used, which are made to agitate with the ore.

A blast of compressed air is blown through the pipe of a rotating agitator to produce froth. The sulphide ore particles are wetted and coated by pine oil and rise up along with the froth (froth being lighter) at the top of mixture in container from which it is collected. The gangue particles wetted by water sink to the bottom of the tank (water being heavier). The froth containing the sulphide ore is transferred to another container, washed and dried. Thus sulphide ore is separated from the gangue. The froth floatation process is shown in the following fig. 16.3.



Froth floatation process for the concentration of sulphide ores

Fig. 16.3 Froth floatation process

Tidbit

Magnetic separation method is used for the separation of magnetic ore from non-magnetic ore by using magnetic separator.

Reading Check

What is froth floatation?

16.1.2 Extraction of Metals

When the ore is free of gangue and concentrated, metal is extracted from it. It is converted into oxide ore.

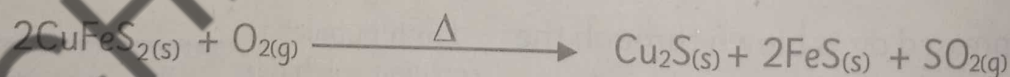
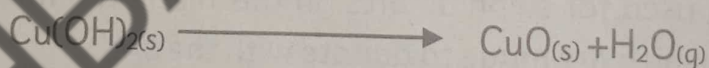
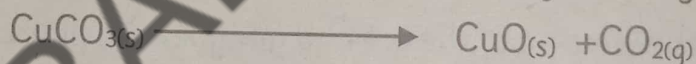
16.1.2.1 Convert the Concentrated Ore to Oxide

It is easier to obtain a metal from its oxide form as compared to its sulphide, carbonate or any other form. Therefore, prior to reduction usually the metal is converted to its oxide form. Following methods are used to convert the concentrated ore to its oxide form.

1. Roasting (Red hot)

The process in which the concentrated ore is heated either alone or with some other materials in excess of air in a furnace.

The concentrated ore is then roasted in a furnace between 500°C and 700°C in the presence of a current of air. Ores of metals such as copper and nickel, when roasted in air, are converted to their oxides and sulphur is oxidized to SO_2 . While ores of some metals like lead (Pb) are partially oxidized and converted into sulphate. The following reactions take place.

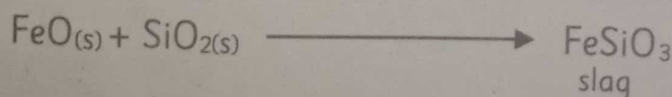
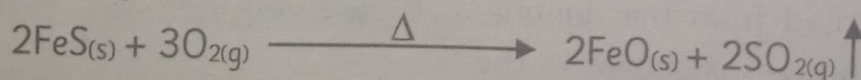


2. Smelting (Formation of matte)

It is a general term used for various operations, where by the metal is separated by fusion from its ore.

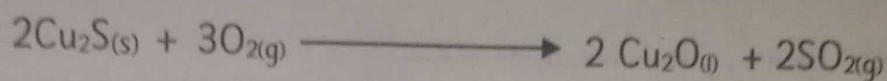
It is the process in which the oxide ore in the fused state is reduced with reducing agents such as coke to get the metal is called smelting

The roasted ore is mixed with coke and sand and smelted into blast furnace. During smelting it gets oxidized to iron oxide (FeO). The iron oxide (FeO) then reacts with silica (SiO_2) forming iron silicate (FeSiO_3) (Slag).

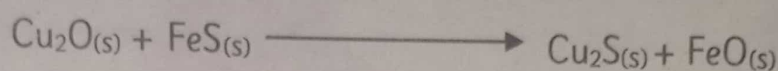


Iron silicate (FeSiO_3) is **slag** (Impurities). It is lighter than molten sulphides of copper and iron hence it is removed at the upper hole.

The cuprous sulphide (Cu_2S) in the blast furnace also oxidizes and form copper oxide (Cu_2O).



The copper oxide (Cu_2O) then reacts with un-reacted iron sulphide (FeS) and form cuprous sulphide (Cu_2S) and iron oxide (FeO).



This FeO also reacts with silica (SiO_2) forming, iron silicate (FeSiO_3) slag.

Molten cuprous sulphide (Cu_2S) with iron sulphide (FeS) is called **matte** and is removed through the slag hole.

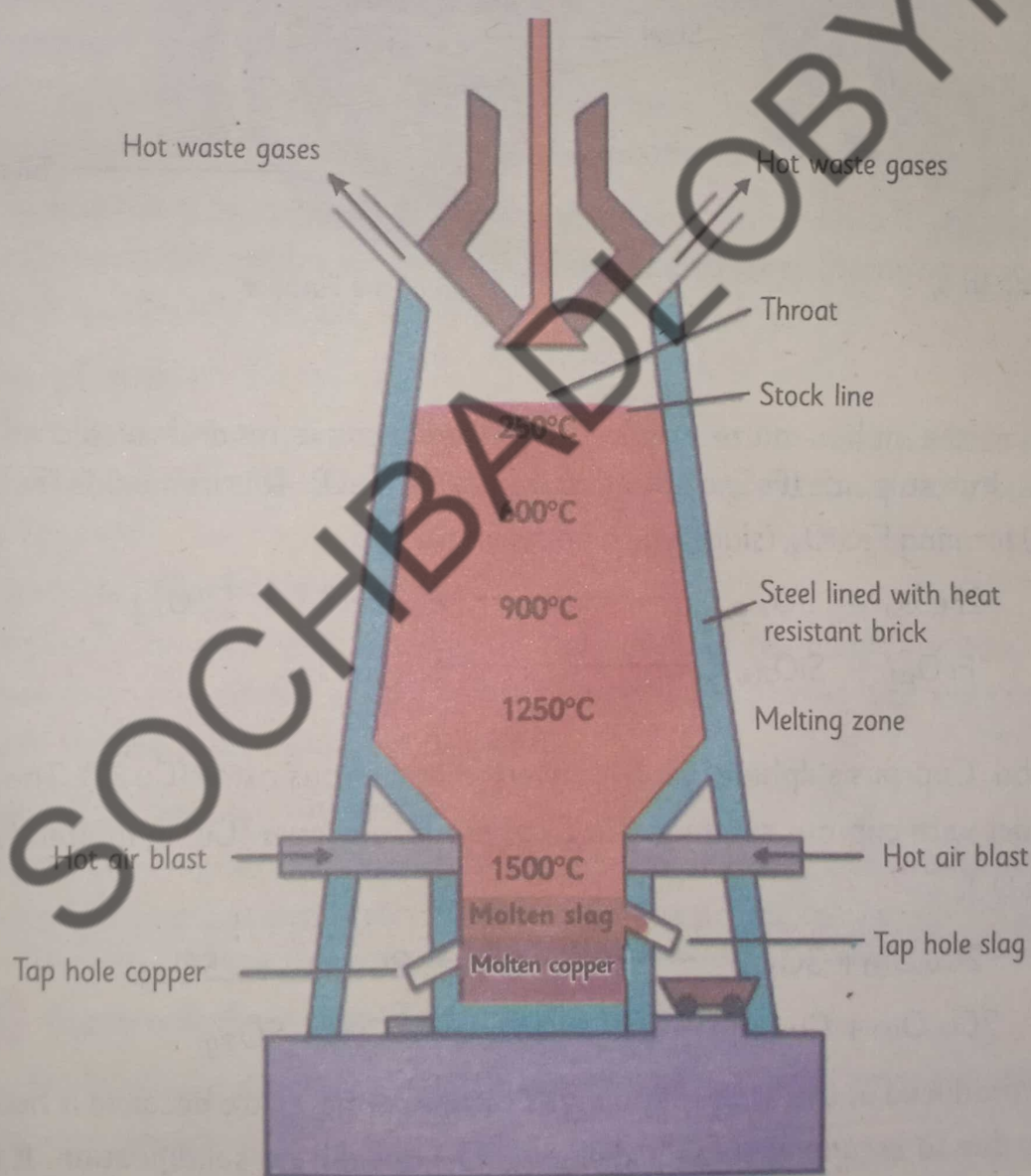


Fig.16.4 Blast Furnace for Smelting of Copper

3. Bessemerization

Bessemer process was invented by Henry Bessemer. The process is carried out in a special kind of egg-shaped or pear-shaped furnace. This furnace is called Bessemer converter.

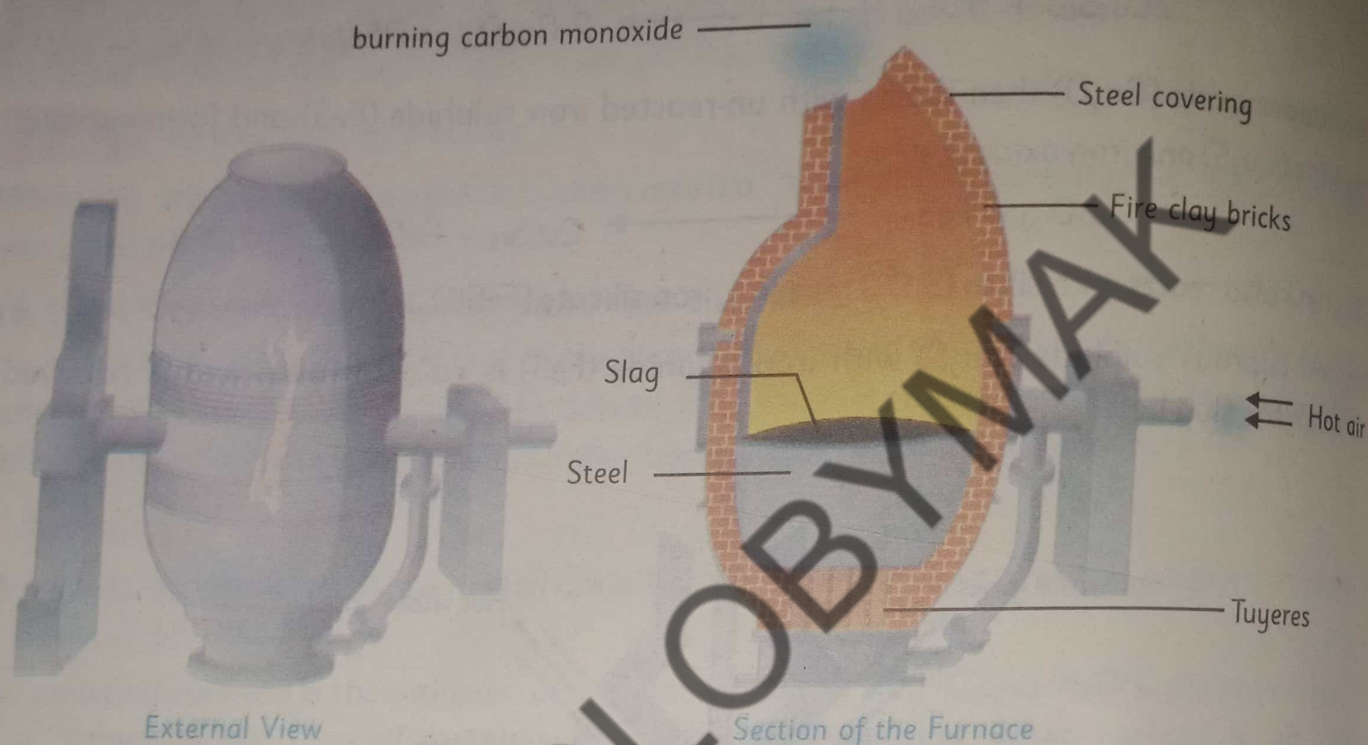
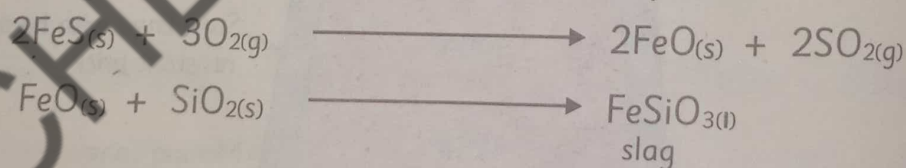
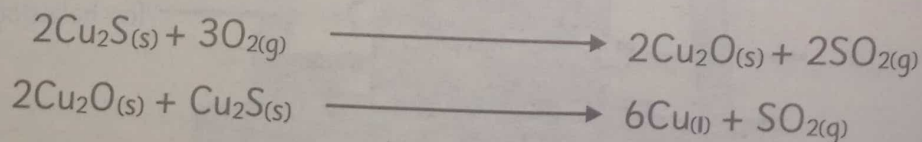


Fig.16.5 Bessemer Converter

In Bessemerization, the molten matte is poured in Bessemer converter and calculated amount of sand is added. Iron sulphide (FeS) oxidized to iron oxide (FeO). This iron oxide (FeO) reacts with sand (SiO_2) forming FeSiO_3 (slag) which floats on the top.



On the other hand, Cuprous sulphide (Cu_2S) converted to cuprous oxide (Cu_2O). The cuprous oxide, (Cu_2O) react with cuprous sulphide (Cu_2S) to produce copper (Cu) in molten form and sulphur dioxide (SO_2).



The copper (Cu) produced in this way is known as blister copper (Cu), because it has porous surface, which is due to escape of sulphur dioxide (SO_2) gas during solidification. It is 95 to 97% pure copper, beside, this it contains iron (Fe), manganese (Mn), silver (Ag), gold (Au), etc.

The Study of Chemistry to Careers in Industry.

There are many career options for someone with a degree in chemistry. Statistically, most chemists work in industry.

The chemical, petrochemical, pharmaceutical, food processing, textile and other industries are areas where most chemists usually seek for employment after completing their studies. There are wide varieties of careers for chemists some of them are

- **Research and Development Chemist:**

Research and development chemists help their industries to research and discover ways to improve their products. They also discover new product which brings more revenue to their industries.

- **Quality Control Chemist:**

Quality control chemists in the industry check that the quality of their industries products is up to the desired standard before they are released into the market.

- **Production Chemist:** Production chemists are responsible for translating the new products developed by the research chemists into manufacturing process. They also check quality of products.

- **Food Chemist:**

Food chemists use their knowledge of chemistry to create food with desirable qualities, such as better taste, longer shelf life, improved nutrition, healthy and safe to consume.

- **Chemical Marketing Career:**

Chemists can also be involved in the marketing of chemical products. In addition to their chemistry background, chemists who wish to pursue a career in marketing will need to take some training in marketing.

- **Technical Service Career:**

It involves creating new applications for the products and producing instructional materials to guide customers on how to use the products.

16.1.3 Electro-Refining or Purification of Metals

Electro-refining of metals is a process of obtaining pure metal from the impure one by the process of electrolysis.

Process of electro-refining

The impure blister copper (Cu) is refined by electrolytic process.

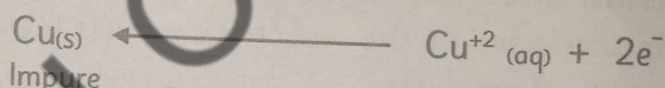
The process of electro-refining of copper involves the following steps:

- A large plate of impure blister copper is made as the anode.
- A thin rod or sheet of pure copper is made as the cathode.
- The electrolyte is copper sulphate (CuSO_4) and dil. Sulphuric acid (H_2SO_4) solution is used.
- The potential difference is 1.3 volt in this process.
- During electrolysis, pure copper is deposited on the cathode plates
- The impurities (Ag, Au and Pt mud along with Cu_2O) in the anode, settle down at the bottom and are removed as anode mud.
- The copper obtained by this method is 99.9 % pure.



Fig.16.6 Electrolytic Refining of Copper Industrially

Anode Reaction:



Cathode Reaction:

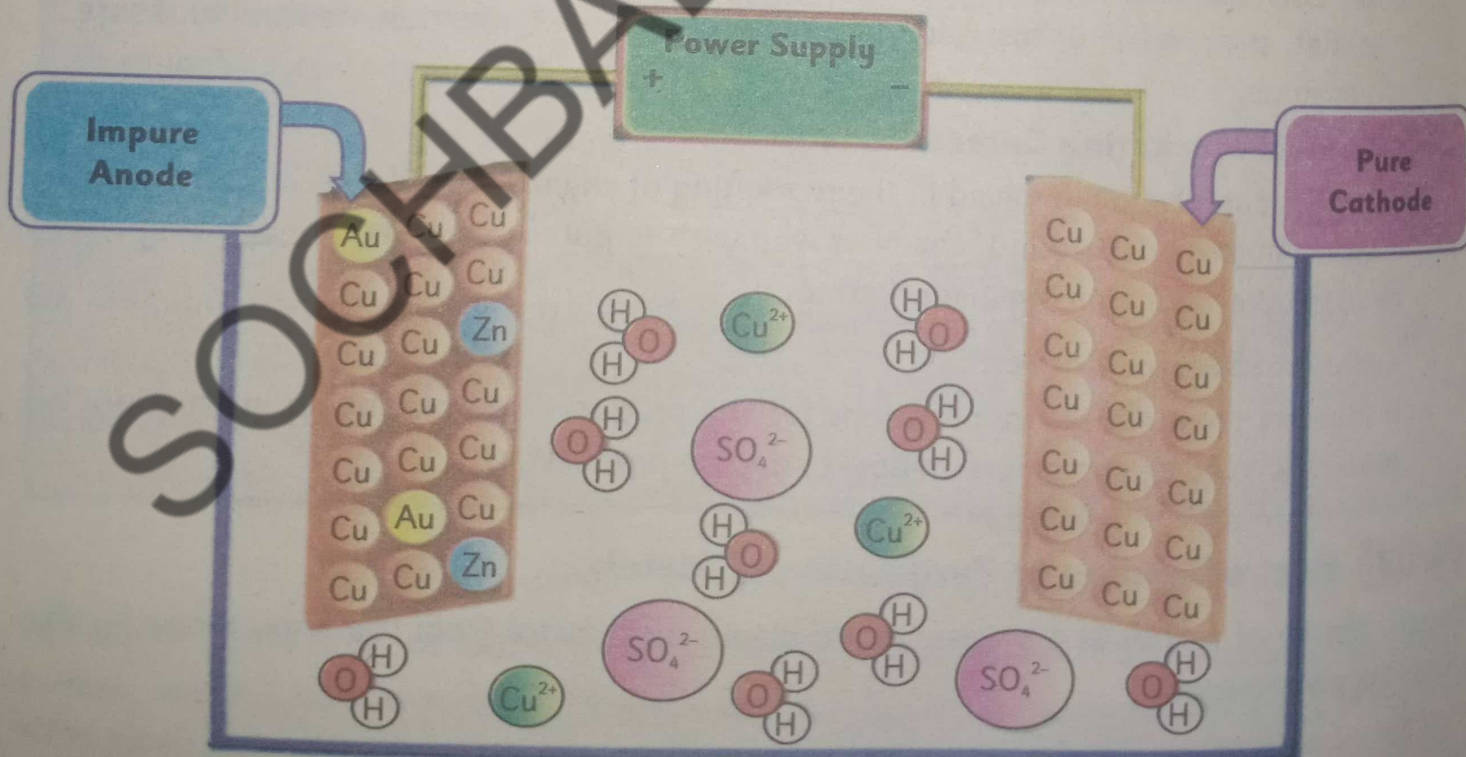


Fig.16.7 Electrolytic Refining of Copper

Self Assessment

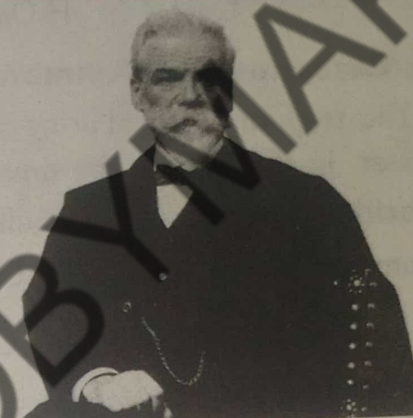
1. What is concentration of ore?
2. Discuss gravity separation or hydraulic washing of ore.
3. What is roasting?
4. What is electro-refining of copper?

16.2 Manufacture of Sodium Carbonate by Solvay's Process

Sodium carbonate (Na_2CO_3) also known as washing soda or soda ash, is a sodium salt of carbonic acid. Most commonly occurs as a crystalline decahydrate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$). Sodium carbonate is domestically well known as a water softener. It is synthetically produced in large quantities from salt (NaCl) and limestone in a process known as the Solvay process.

Ernest Solvay was a Belgian chemical engineer. He prepared sodium bicarbonate (NaHCO_3) and sodium carbonate (Na_2CO_3) for the first time from cheap and abundantly available raw material such as limestone and sodium chloride (NaCl).

On industrial scale sodium carbonate is prepared by Solvay process.



Ernest Solvay

16.2.1 Raw materials

The raw materials used for manufacture of sodium carbonate are

- | | |
|--------------------------------------|------------------------------------|
| i. Sodium Chloride (NaCl) | ii. Lime Stone (CaCO_3) |
| iii. Ammonia (NH_3) | iv. Water (H_2O) |

16.2.2 Basic reactions

Solvay process consists of following steps.

i. Preparation of brine solution

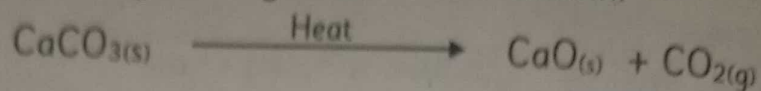
At first step, a saturated solution of sodium chloride is prepared which is also known **Brine**.

ii. Preparation of Ammonical Brine

In this step, saturated brine solution is allowed to flow down in ammoniating tower. This tower is fitted with mushroom shaped baffles, which ensure the proper mixing of ammonia gas in brine. Ammonia is dissolved in brine (sodium chloride solution).

iii. Preparation of Carbon dioxide and Slaked Lime

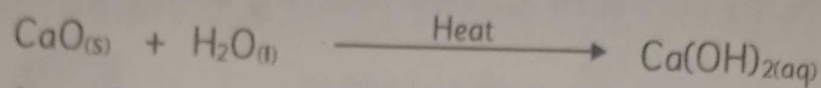
Carbon dioxide is produced by heating limestone in limekiln.



Carbon dioxide is fed into the carbonating tower from the top. Calculated amounts of quick lime (CaO) and water are mixed to produce slaked lime Ca(OH)_2 .

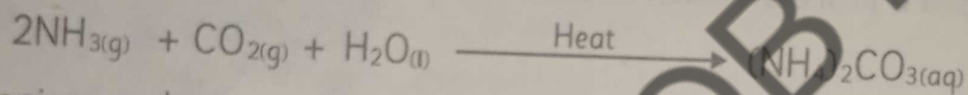
Reading Check

What is ammoniated of Brine?

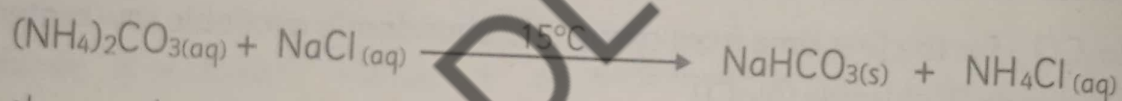


iv. Carbonation of Ammonical Brine

In this step, ammonical brine is allowed to enter the carbonating tower also known as solvay tower. In this tower, the ammonical brine is mixed with carbon dioxide gas. The carbon dioxide is converted into small bubbles. Carbon dioxide (CO_2) reacts with ammonia to form ammonium carbonate $(\text{NH}_4)_2\text{CO}_3$.



Ammonium carbonate reacts with sodium chloride (NaCl) and form sodium bicarbonate (NaHCO_3) and ammonium chloride (NH_4Cl).



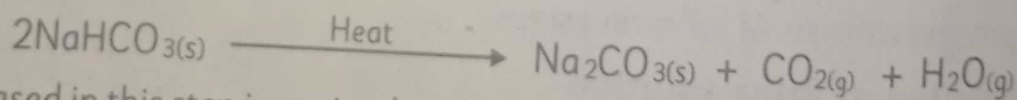
Due to the exothermic nature of above reaction, solubility of NaHCO_3 increases. The temperature of the mixture is lowered to 15°C . At this temperature, NaHCO_3 is precipitated.

v. Filtration of precipitate

The precipitate of sodium bicarbonate (NaHCO_3) is separated from the solution by filtration from the carbonating tower. It is used as baking soda.

vi. Calcinations

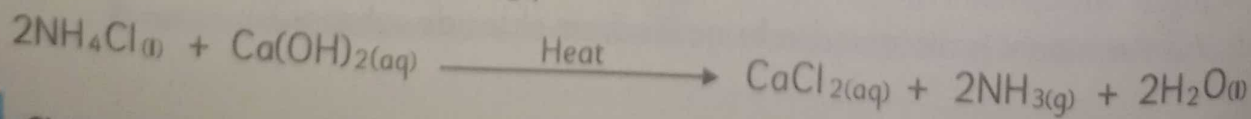
Dry sodium bicarbonate is heated in rotatory furnace called **calciner**, to give anhydrous sodium carbonate or soda ash.



Carbon dioxide released in this step is re-circulated in carbonating tower.

vii. Recovery of ammonia

Ammonia is recovered from ammonium chloride solution produced in the Solvay (carbonated) tower and slaked lime formed in limekiln. Slaked lime is heated with Ammonium chloride to form Ammonia and calcium chloride (by product).



Almost all the Ammonia is recovered in this process and is used again in this process. The products sodium carbonate and sodium bicarbonate are important industrial chemicals and used in many products.

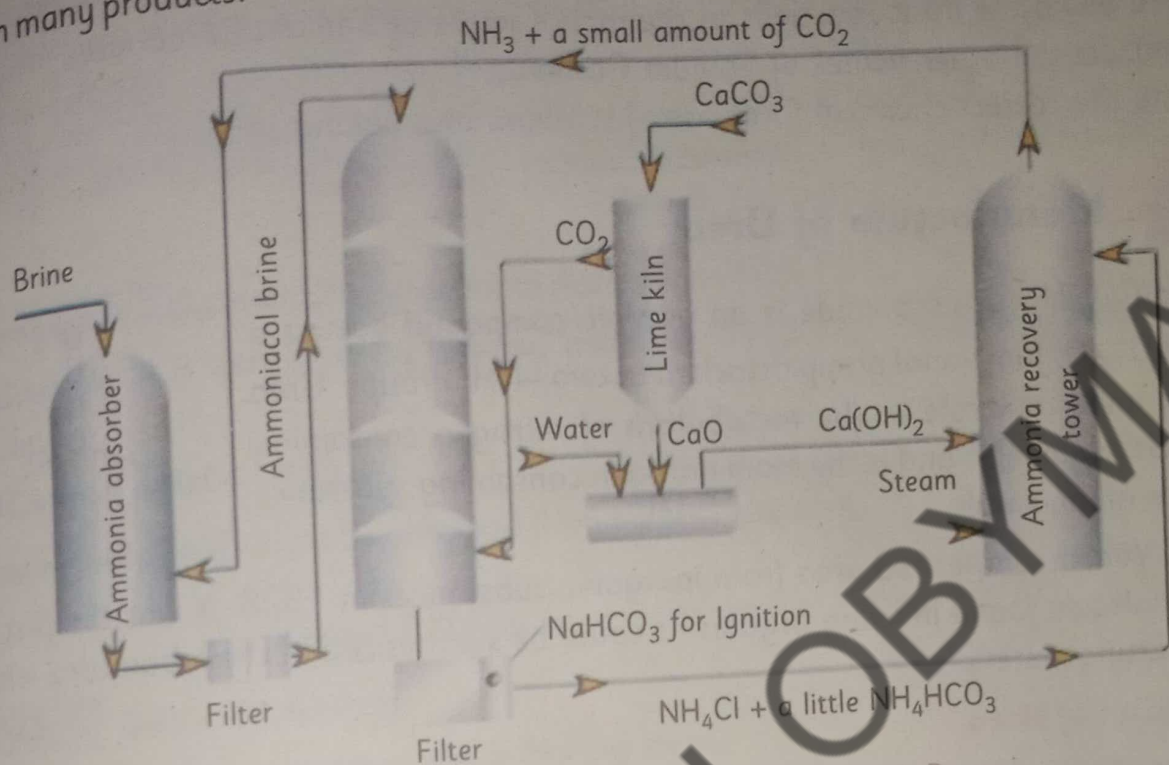


Fig. 16.8 Manufacture of Sodium Carbonate by Solvay's Process

16.2.3 Flow Sheet diagram of Solvay's Process

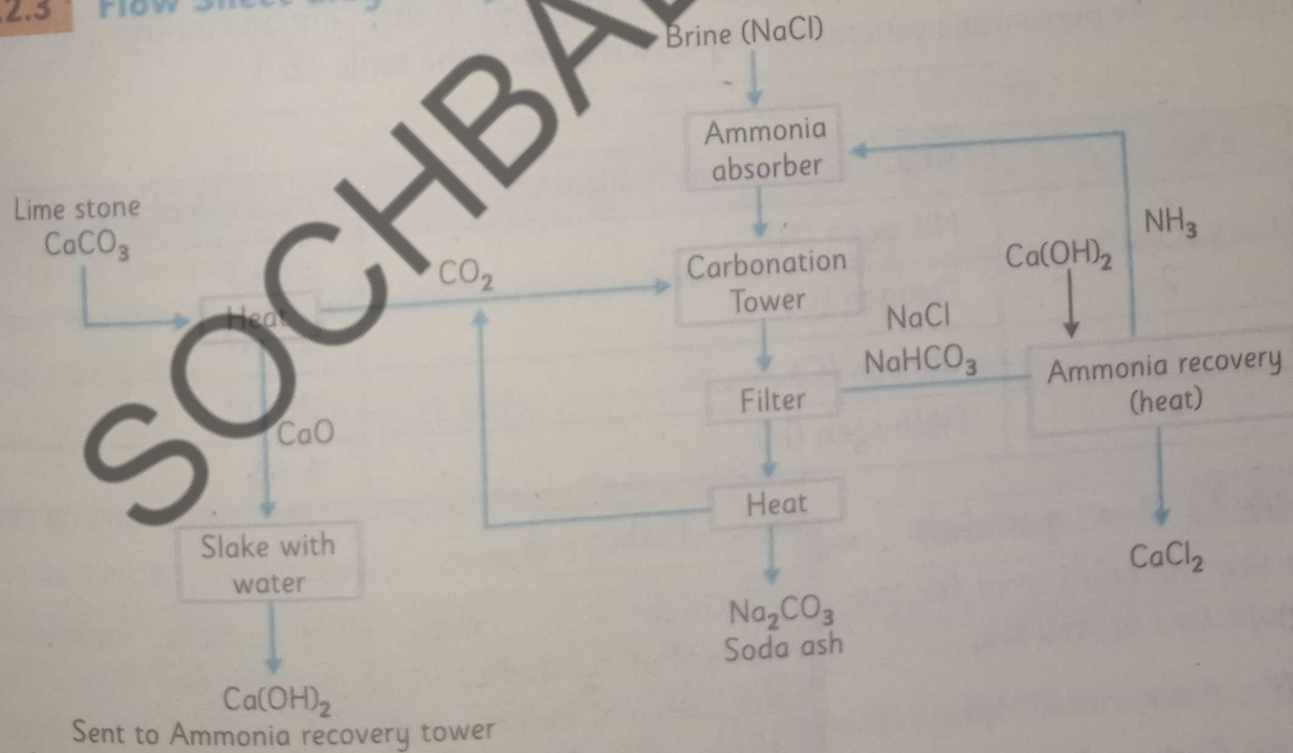


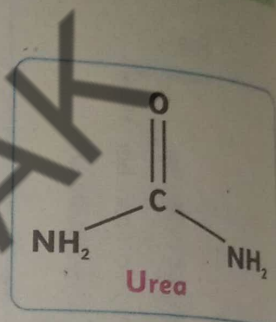
Fig. 16.9 Flow Sheet Diagram of Solvay's Process

Self Assessment

1. What are the raw materials used in the manufacture of Sodium Carbonate?
2. Write down the basic reactions in the manufacture of Sodium Carbonate
3. What are the other names of Sodium Carbonate?
4. Write the correct chemical formulae of washing and baking soda.

16.3 Manufacture of Urea

Urea (NH_2CONH_2) or carbamide is an organic compound having a carbonyl ($\text{C}=\text{O}$) functional group attached to two $-\text{NH}_2$ groups. Urea serves an important role in the metabolism of nitrogen containing compounds by animals and is the main nitrogen containing substance in the urine of mammals.



Friedrich Wöhler synthesized urea from inorganic substances in 1828. It was the first time that the molecule found in living organisms could be synthesized in the laboratory without organic starting materials.

Composition of Urea

Urea is one of the most important nitrogenous fertilizers. It has the highest nitrogen content available in a solid fertilizer (46.67%). It dissolves readily in water. It leaves no salt residue after use on crops. In addition to fertilizer, it is also used in daily life and industry for various purposes. The percentage composition of urea is given in the table 16.1.

Table 16.1 Percentage Composition of Urea

S.No	Element and their Symbol	Percentage (%)
1	Nitrogen (N)	46.67
2	Oxygen (O)	26.67
3	Carbon (C)	20.00
4	Hydrogen (H)	6.66

16.3.1 Raw materials

The raw materials used for the manufacture of urea are,

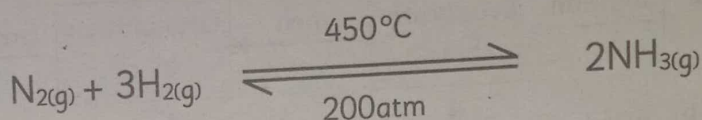
- (i). Ammonia (NH_3)
- (ii). Carbon dioxide (CO_2)

Tidbit

Fertilizer is any material, organic or inorganic, natural or synthetic, which supplies one or more of the chemical elements required for the plant growth. Three elements namely nitrogen, phosphorus and potassium are very essential for the growth of plants.

(i). Ammonia (NH₃)

Ammonia is prepared by Haber process. In this process, nitrogen and hydrogen react when they are passed over iron catalyst at 450°C and 200 atmospheric pressure. It produces Ammonia (NH₃).

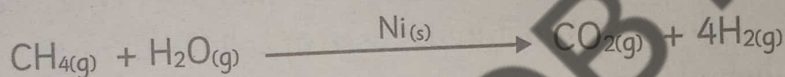


Nitrogen: It is obtained from fractional distillation of air.

Hydrogen: It is prepared by passing methane (CH₄) and steam over heated nickel as catalyst.

(ii) Carbon dioxide (CO₂)

Carbon dioxide (CO₂) can be obtained from natural gas (CH₄).

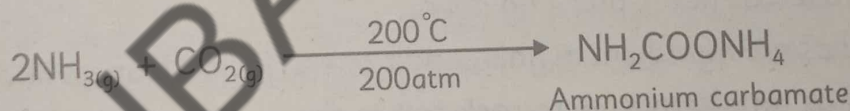


16.3.2 Basic Reactions

Manufacture of urea involves the following steps.

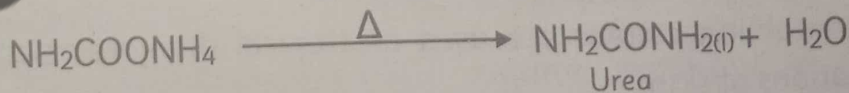
(i) Reaction of Ammonia and Carbon Dioxide

Ammonia and Carbon dioxide are heated at 170 – 200°C and 100 to 200 atmospheric pressure to form ammonium carbamate.



(ii) Urea Formation

When the ammonium carbamate is heated it decomposes. On decomposition it produces urea and water.



(iii) Evaporation and Granulation of Liquid Urea

In this step, the liquid urea is concentrated in vacuum evaporators. It is sprayed from top of tower under pressure and hot current of air is introduced from the bottom in opposite direction. It evaporates the water from liquid urea. It is rapidly cooled and sent to the granules/tower. This urea is stored to be marketed.

Reading Check

What is granulation?

16.3.3 Flow sheet diagram

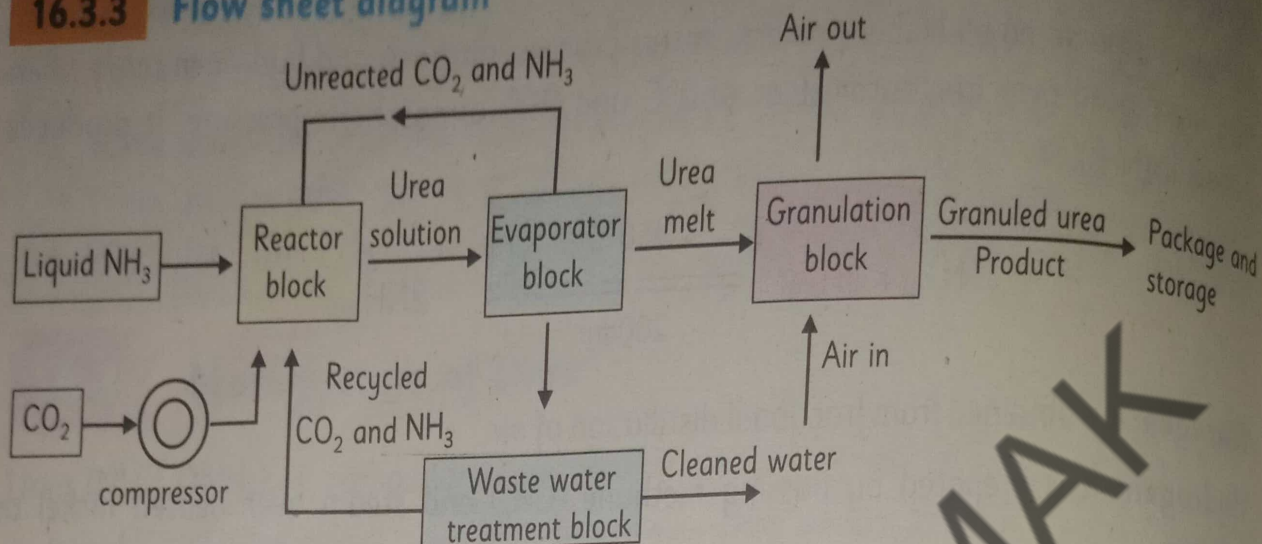


Fig. 16.10 Flow Sheet Diagram of Manufacture of Urea

Uses of Urea

It is a white crystalline organic compound. It is important due to the following usage:

- i. About 86 % of Urea manufactured is used as solid fertilizer.
- ii. Urea-formaldehyde resins have large use as a plywood adhesive / glues.
- iv. Melamine-formaldehyde resins are used as dinnerware and for making extra hard surfaces.
- v. Urea can be used to make urea nitrate, which is highly explosive.
- vi. Urea is used as raw material for manufacture of many important chemical compounds like plastic, resins, various adhesives etc.
- vii. Urea is used as flame proofing agent.
- viii. It is used as an ingredient in hair conditioners, facial cleaners and lotions.
- ix. It is used as an alternative to rock salt in the deicing roadways and runways. It does not promote metal corrosion to extent that salt does.
- x. A flavour enhancing additive for cigarette.
- xi. A main ingredient in hair remover creams.
- xii. Urea containing creams are used as tropical dermatological products to promote rehydrations of skin.

Self Assessment

1. What are the raw materials used in the manufacture of urea?
2. Write down the basic reactions in the manufacture of urea.
3. What are the uses of urea?
4. Calculate the percentage of nitrogen in urea.

Hint: Percentage of Element = $\frac{\text{Atomic Mass of Element} \times \text{No of atoms in compound}}{\text{Molecular Mass of the compound}} \times 100$

Activity 16.1

Class debate

Debate topic: Increasing the use of artificial fertilizers is the best solution to meet the growing food needs of the world's human population.

Instruction:

Divide the class into two groups to debate on the above topic:

- One group should take the position of agreeing with the statement and the other should disagree.
- Teacher will set the norms for the discussion.
- Teacher will explain to you how to proceed with the debate.
- In your group, discuss reasons and record notes of your discussions.

Society, Technology And Science

The Use of Synthetic Fertilizers Versus Organic / Natural Fertilizers.

A fertilizer is any material, which is added to the soil to increase the soil fertility, enhance plant growth and increase production. These fertilizers may be synthetic or organic/natural fertilizer in nature. Synthetic fertilizers are wholly or partially obtained from synthetic source. Organic fertilizers are derived from the remains or byproducts of natural organisms, which contain the essential nutrients for plant growth.

Synthetic Fertilizers	Organic / Natural Fertilizers
1. Synthetic fertilizers are commercially produced from petroleum or natural gas and are easy to apply in granular or liquid form.	Most organic fertilizers are derived from plants and animals like manure, bone, blood, meat etc. that is broken down by bacteria before they can be used by plants and soil.
2. These are artificially prepared.	These are prepared naturally.
3. Synthetic fertilizers leach from the soil with watering and can be used by plants instantly.	The organic fertilizers are naturally decomposed slowly by soil microbes to release vital nutrients over a longer period of time. Therefore, they are for entire season.
4. Nitrogen, phosphorus and potassium (NPK Ratio) is about 20 to 60%	Nitrogen, phosphorus and potassium (NPK Ratio) is about 14 %

5. Chemical fertilizers are rich equally in three essential nutrients that are needed for crops.	Adds natural nutrients to soil, increases soil organic matter and improves soil structure. It also improves water-holding capacity, reduces soil-crusting problems and reduces erosion from wind and water.
6. Equal distribution of three essential nutrients, such as nitrogen, phosphorous, potassium.	Unequal distribution of essential nutrients, such as nitrogen, phosphorous, potassium.
7. Chemical fertilizers are generally cost effective and readily in greater amounts. They have more nutrients.	Depending on the type of organic fertilizer used, it can be more expensive than synthetic fertilizers.
8. Synthetic fertilizers are easy to use as they seep into the soil deep as soon as water is applied.	Organic fertilizers are present on surface and lot of work is required to mix them with the soil.
9. They immediately supply nutrients to the earth.	They slowly release the nutrients to the earth.
10. These fertilizers are usually basic in nature. They are neutral to skin.	Several natural fertilizers are acidic in nature. They can burn the skin. In addition they can change soil fertility by increasing its acidity.

16.4 Petroleum Industry

Many useful materials on which modern life depends are produced by the petrochemical industry, such as fuels, solvents, lubricants, polymers, detergents etc. Crude oil cannot be used directly but must be refined before use. Commercially useful products are produced by the petrochemical industry (collectively called petrochemicals). Crude oil is an important raw material and the source of many useful substances such as fuels and a chemical feedstock for the petrochemical industry, from which endless products, including plastics and drugs are produced.

16.4.1 Petroleum

The word "petroleum" is a combination of two Latin words "**Petro**" means "**Rock**" and "**Oleum**" means "**Oil**". The petroleum is crude oil. It is present as dark viscous liquid under the ground at different depths. The petroleum is mainly composed of Hydrocarbons.

16.4.2 Origin of petroleum

Nothing definite can be said about the origin of petroleum, because man is familiar with its use from ancient time. Chinese used petroleum as fuel as early as 200B.C. There are two theories about the origin of petroleum.

i. Inorganic or Abiotic origin

This theory was put forward by a Russian chemist Mendeleev. He proposed that steam reacted with metallic carbides at high temperature and pressure under the surface of the earth produced petroleum. This theory did not gain popularity.

ii. Organic origin

According to this theory, the remains of plants and animals were buried under the soil millions of years ago. These dead organic matter were converted into petroleum by the action of bacteria under the influence of temperature and pressure of the earth. These deposits trapped between the layers of nonporous rocks. The oil and gas thus formed could not come out and collected underground. This theory gained popularity.

16.4.3 Occurrence of Petroleum

Deposits of petroleum are found at about 200–1000 feet below the earth surface. The richest deposits of petroleum are located in Saudi Arabia, Iran, Iraq, Kuwait, United Arab Emirates (UAE) and other Middle East countries. Russian federation and central Asian states have also rich oil deposits. Petroleum is also found in central African states such as Libya, Nigeria, Venezuela, Mexico, Canada, and United States of America (USA).

In Pakistan search for petroleum is being done on priority basis. Some oil is being extracted from Meyal and Tut in Pothohar areas of Punjab, Badin and Hyderabad districts of Sindh, Kohat and Kark district of Khyber Pakhtunkhwa.

Its composition varies according to its place of occurrence. It exists in all three states of matter. In the solid form, it is called as **asphalt**, in the liquid it is known as **crude oil**, whereas in gaseous form it is called **natural gas**.

16.4.4 Drilling of Petroleum

Petroleum usually occurs at depth of 500 feet or more. The crude oil is found in porous rocks. It is often associated with natural gas which exerts pressure on the oil surface and drives it out through natural opening of earth.

In the case of artificial mining, mines are bored. When the oil pocket is pierced the gas pressure, forces the oil out. If there is no natural gas present in pocket, air pressure is applied to raise the oil from the well. The oil obtained from the mine is conveyed by system of pipe lines to the refinery for refining.

Drilling

The art and science of mining a hole in the earth crust or rocks is called drilling.

Reading Check

What is petroleum?

Tidbit

In fractional distillation, a mixture of different liquids is evaporated then condensed. Different liquids are evaporated according to their boiling point and they are collected in different chambers of distillation.



Fig.16.11 Oil Refinery

Society, Technology And Science

Different Types of Fire (Wood, Oil and Electric) Require Different Chemistry to Put Them Out.

Fire is grouped into five different Classes. In order to control the fire it is considered important to know the class of fire because each class of fire requires different method to control. By using the wrong technique to control the fire, you could make the fire much more worse. Here, we shall discuss the five different Classes of fire and will try to know how to control them.

Class A Fires

Class A fires are those that involve ordinary materials such as wood, rubber, cloth, paper and plastics. You need to use a fire extinguisher with an 'A' label on it, which is specifically

designed for Class A fires. If there is no fire extinguisher available, you can use water to extinguish a Class A fire, if it is safe to do so.

Class B Fires

Class B fires are fires that involve flammable liquids such as petrol, oil-based paints, lacquers, alcohol, diesel oil or flammable gases. However, there are some types of chemical fire extinguisher that can be used with both Class A and B fires. These are filled with foam or powder and pressurized with nitrogen.

Class C Fires

Class C fires are fires that involve electrical equipment, including wiring, plug sockets, appliances and circuit breakers. You may be at risk of electric shock if you put water on an electrical fire, so make sure you only use a Class C fire extinguisher to put an electrical fire

Class C fire extinguishers contain dry chemical fire dampeners, and may be filled with simple sodium bicarbonate or potassium bicarbonate. This type of extinguisher can be used on B and C type fires.

There are multipurpose extinguishers, which can be used, for type A, B and C fires and contain mono-ammonium phosphate, which is a dry yellow powder. It leaves a nasty residue, which needs to be cleaned up as soon as the electrical fire is out, to prevent further damage.

Class D Fires

Class D fires involve metals such as magnesium, titanium and sodium. Class D fire extinguishers are usually only found in chemical laboratories and can only be used for Class D fires.

16.4.4 Important Fractions of Petroleum

When crude oil is pumped out of the ground, it is a mixture of a large number of compounds most of which are hydrocarbons. Hydrocarbons, are compounds composed of hydrogen and carbon atoms only. *The conversion of crude oil into useful products with different boiling range and free from impurities is called refining*, which is carried out in a fractionating column. Fractionating column have different compartment to collect different fractions.

The complex mixture of hydrocarbons in crude oil can be separated into fractions by the technique of fractional distillation. Petroleum is refined by fractional distillation in a tall fractionating column (tower), as shown in the figure 16.12. The crude oil is heated up to 400°C under high pressure in a furnace. Then it is passed through the fractional distillation column. These vapours rise through the column. As hot vapours move up, they condense according to their boiling points into various fractions. Compounds with highest boiling points condense first near the bottom, while those compounds having low boiling points

move to the top of fractionating column. The vapours condense gradually at different levels according to their boiling points. The crude oil is separated in different fractions.

Small molecules

- Low boiling point
- Very volatile
- Flows easily
- Ignites easily

fractions
decreasing in
density and
boiling point

fractions
increasing in
density and
boiling point

crude oil

heating

Large molecules

- High boiling point
- Not very volatile
- Does not flows easily
- Does not ignites easily

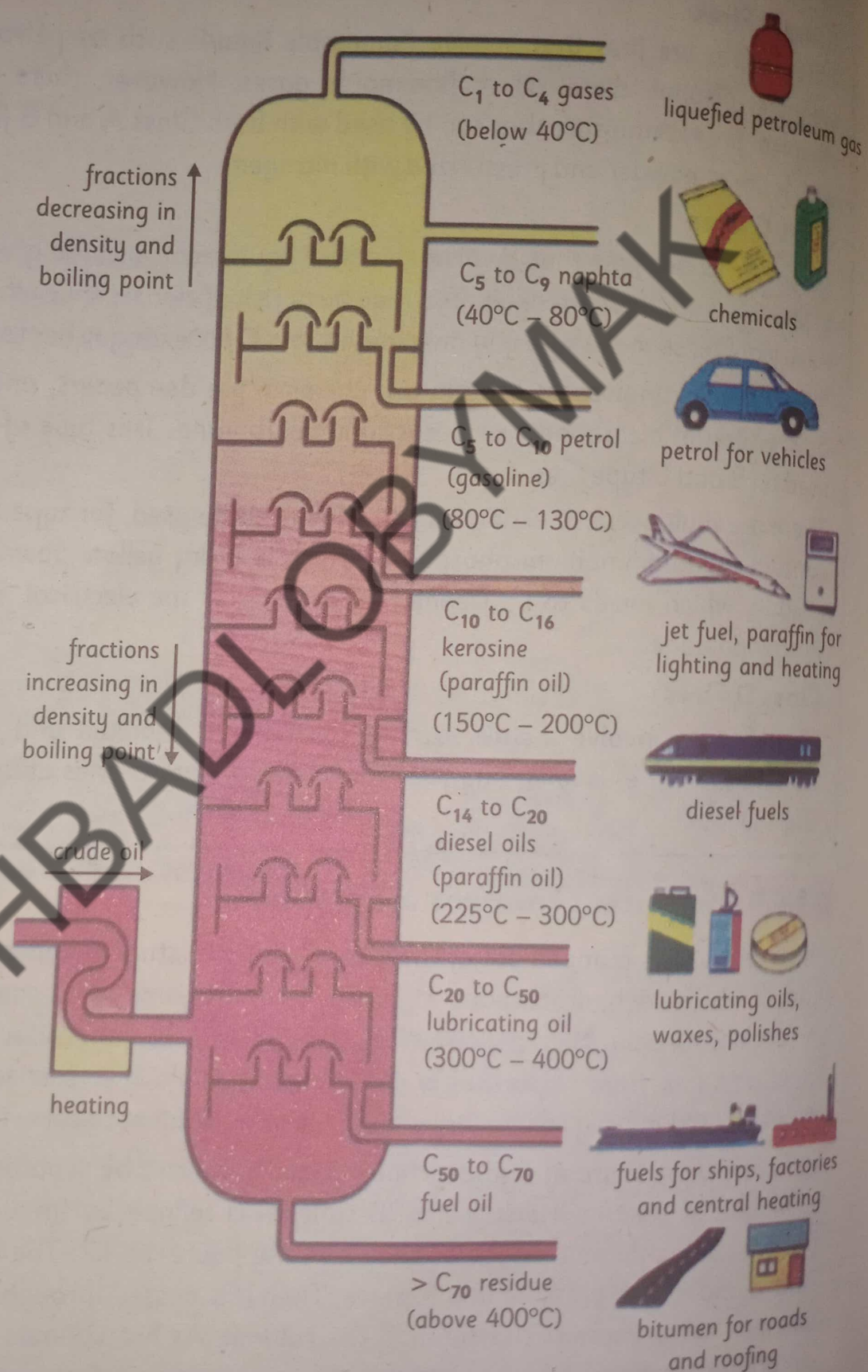


Fig.16.12 Fractionating Column (Tower)

Table 16.2 Fractions of Petroleum and their Important Uses

S. No	Fraction	Number of carbon atoms per molecule	Boiling point	Important uses
1	Refinery Gas	C_1 to C_4	below 40°C	Methane, CH_4 (domestic heating), ethane another gaseous fuel, carbon-3 and carbon - 4 easily liquefied petroleum gas, portable energy source e.g. gas for heating and cooking (propane, butane), feedstock for other organic chemicals Butane for camping gas.
2	naphta-petrol (gasoline)	C_4 to C_{12}	40 to 130°C	Not a good fuel, but valuable raw material of organic chemicals, used as a solvent and important chemical and as light engine oil e.g. car fuel.
3	kerosene (Paraffin oil)	C_{10} to C_{16}	150 to 200°C	Less volatile, less flammable than petrol, used for domestic heating fuel, (paraffin), aircraft jet fuel (kerosene)
4	Diesel Oils	C_{14} to C_{25}	225 to 300°C	Less volatile than petrol, used as a fuel in large vehicle such as trucks, trains etc, also cracked to make more petrol and alkenes
5	Lubricating Oil	C_{20} to C_{70}	300 to 400°C	Viscous (sticky) and used as lubricating oils and greases.
6	Residue (Bitumen/ Asphalt)	above C_{70}	above 400°C	The larger molecules make bitumen/ asphalt – low melting solid used on roads as it forms a thick, black, tough and resistant adhesive surface on cooling, also used as a roofing waterproofing material.

Self Assessment

1. Discuss the origin of petroleum.
2. Define fractional distillation.
3. Write down the names of fractions and one use of each fraction.
4. What is Oil Refinery?
5. What is asphalt?

Key Points

- Metallurgy is the science that deals with the procedures used in extracting metals from their ores, purifying and alloying metals and creating useful objects from metals.
- The majority of metals are usually found in combined form having definite chemical composition. The naturally occurring metallic compounds are called minerals.
- An aggregate of mineral and other impurities is known as ore. A naturally occurring solid material from which a metal or valuable mineral can be extracted profitably is called an ore.
- Gangue is the earthy materials such as sand, rock, clay and other impurities attached with the ores.
- Those metals which have low chemical reactivity generally occur in native or free form.
- Those metals which are chemically reactive or affected by air and water generally occur in combined state.
- Concentration of Ore is the removal of useless rocky portion of the ore.
- Pulverization is the breaking of the ores into small pieces with the help of crushers or grinders and further reduced to fine powder with the help of a ball mill or stamp mill.
- Froth floatation method is based on the wetting of the ore and gangue with pine oil and water.
- In roasting (Red hot) process the concentrated ore is heated either alone or with some other material in excess of air in furnace.
- In smelting, the oxide ore in the fused state is reduced with reducing agents such as coke to get the metal.
- Electro-refining of metals is a process of obtaining pure metal from the impure one by the process of electrolysis.
- Sodium carbonate (Na_2CO_3) is also known as washing soda or soda ash.
- Urea is one of the most important nitrogenous fertilizers.
- Fertilizer is any material, organic or inorganic, natural or synthetic, which supplies one or more of the chemical elements required for the plant growth.
- The word petroleum is a combination of two Latin words "Petro" means "Rock" and "Oleum" means "Oil".

Exercise

A. Choose the Correct Option.

1. When Sodium Bicarbonate is heated to get sodium carbonate, all are produced except
a. CO b. CO₂ c. Na₂CO₃ d. H₂O
2. Froth flotation process is concentration of ore by
a. Magnetically b. Wetting the ore
c. Difference in density d. Chemically
3. All are the raw materials for the manufacturing of soda ash except
a. Ammonia b. Brine
c. Lime stone d. Carbon monoxide
4. Matte is a mixture of
a. CuS and FeS b. Cu₂S and FeS
c. Cu₂O and FeS d. Cu₂O and FeO
5. The impurity present in mineral is called
a. Metal b. Ore c. Gangue d. Salt
6. All are the raw materials for the manufacturing of urea except
a. CO₂ b. NH₃ c. H₂O d. NaCl
7. Percentage of nitrogen in urea is
a. 14 b. 28 c. 60 d. 46
8. Blister copper is refined through
a. Concentration b. Reduction c. Smelting d. Electrolysis
9. Petroleum is separated into different fractions by the process of
a. Simple distillation b. Condensation
c. Fractional distillation d. Destructive distillation
10. All steps are used for the extraction of metals except
a. Roasting b. Smelting c. Evaporation d. Bessemerization

B. Short questions

1. How could you convert NaHCO₃ into Na₂CO₃?
2. Enlist the different uses of urea?
3. Differentiate between mineral and ore.
4. Define metallurgy. What are its steps?

5. What is the function of froth floatation process.
6. On what basis the different fractions of petroleum are separated?
7. What is slaked lime? How slaked lime is produced?
8. Assess the composition of urea and calculate the percentage of nitrogen in it.
9. What is gangue and where it is found?
10. How blister copper is purified?

C. Long Questions

1.
 - a). How could you convert the concentrated ore to its oxide?
 - b). How would you use the Roasting in extraction of copper?
 - c). What inference can you make of smelting in extraction of copper?
 - d). Can you elaborate the reason of electro-refining of copper.
2.
 - a). List the raw materials used in Solvay process?
 - b). What basic reactions would you use to support the manufacture of soda ash?
 - c). Predict the byproducts in the Solvay process?
 - d). Sketch the flow sheet diagram of the Solvay process.
3.
 - a). Enlist the raw materials used in the manufacture of urea?
 - b). What basic reactions would you use to support the manufacture of urea?
 - c). What is the advantage of recycling of unreacted compound in manufacture of urea?
 - d). Sketch the flow sheet diagram of the urea manufacture process.
4.
 - a). Define refining of petroleum. Describe the composition of petroleum?
 - b). What are the two theories about the origin of petroleum?
 - c). Write a detail note on fractional distillation of petroleum.
5.
 - a). Write a detail note on metallurgical operations.
 - b). Explain the process of smelting and bessemerization with reference to copper extraction.
 - c). Enlist the different uses of urea.

Project

1. Examine the labels of at least five fertilizers. Note what is the composition of these brands. On what basis they are classified. Explain why each fertilizer has its own particular application. (Consider factors such as the cost of raw materials, the ease of manufacturing, per unit cost, delivery, and so forth).
2. Research the physical properties of these fertilizers and find out how each is manufactured and used.

MCQs Answers

	1	2	3	4	5	6	7	8	9	10
Unit 9	d	c	d	c	a	c	d	d	d	b
Unit 10	c	c	d	c	c	b	d	c	b	b
Unit 11	b	b	c	c	b	c	b	a	b	d
Unit 12	c	a	c	c	b	c	c	d	d	b
Unit 13	c	c	c	c	c	c	d	c	d	b
Unit 14	c	b	b	d	c	b	d	d	c	d
Unit 15	d	d	d	a	a	c	d	a	b	a
Unit 16	d	b	d	b	c	d	d	d	c	c