CHAPTER 16

CHEMICAL INDUSTRIES

Q1. Do you know the chemical name of dhobi soda or washing soda?

Ans: Sodium Carbonate Decahydrate $Na_2CO_3.10H_2O$.

Q2. List important ores of iron, copper, aluminium, sodium, lead, zinc, mercury, chromium, tin and silicon.

Ans: some important ores:

Metal	Name of ore	Formula
Iron	Haematite	Fe_2O_3
Iron	Magnesite	Fe_3O_4
Copper	Chalcopyrite	$CuFeS_2$
Aluminium	Bauxite	$A_2O_3.xH_2O$
Sodium	Halite	NaCl
Lead	Galena	PbS
C	Zinc blende	ZnS
Mercury	Cinnabar	HgS
Chromium	Chromite	$FeO.Cr_2O_3$
Tin	Cassiterite	SnO_2
Silicon	Silica	SiO_2

Q3. Define mineral, gangue and ore.

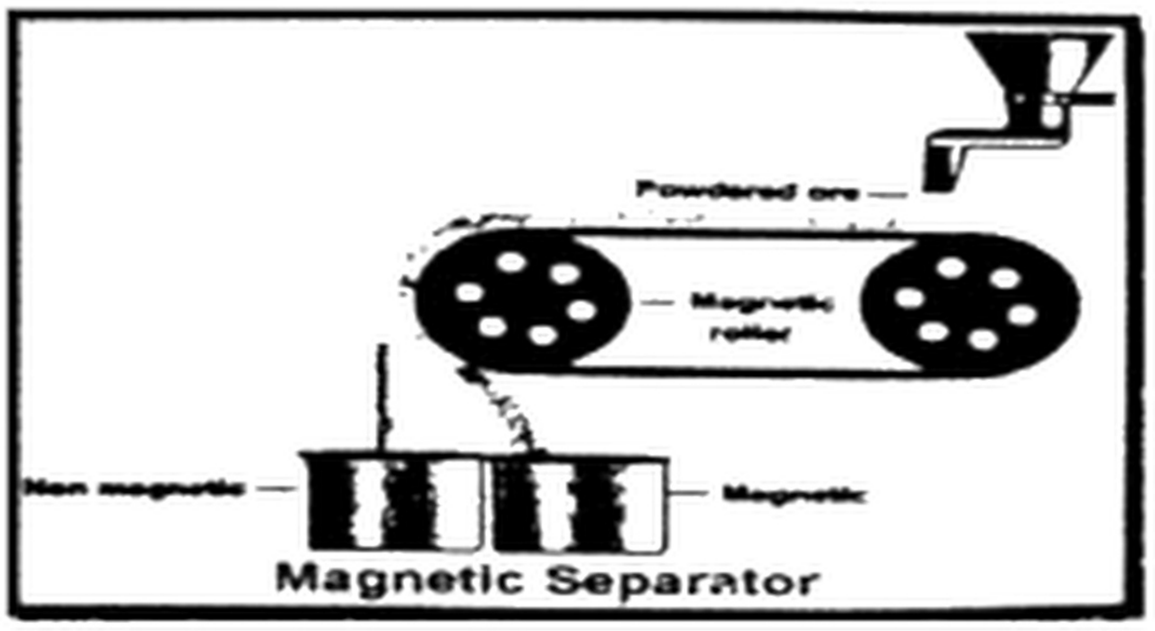
Gangue:

The debris, such as sand, rock and clay attached with the mineral is called gangue.

Ore: An ore is a solid deposit containing a sufficiently high percentage of a mineral to make extraction of metal economically feasible.

Q4. Explain the process of magnetic separation.

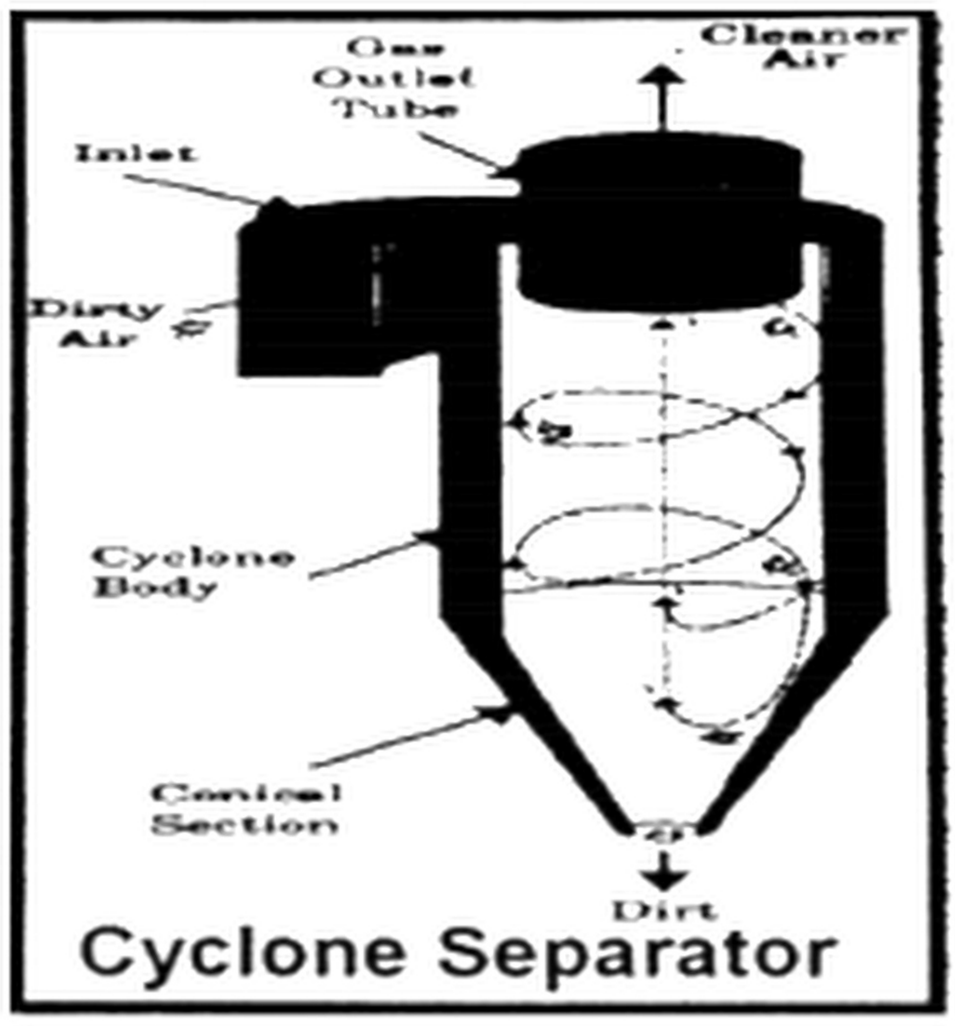
Ans: For magnetic ore, a magnet is used to remove mineral, leaving the gangue behind. The powered ore is dropped over a moving belt. Belt moves over two wheels, one of which is magnetic. It attracts the magnetic ore, so it falls nearer to the magnetic wheel. While non-magnetic impurities fall further away.



Magnetic Separator

Q5. Explain the process of cyclone separation.

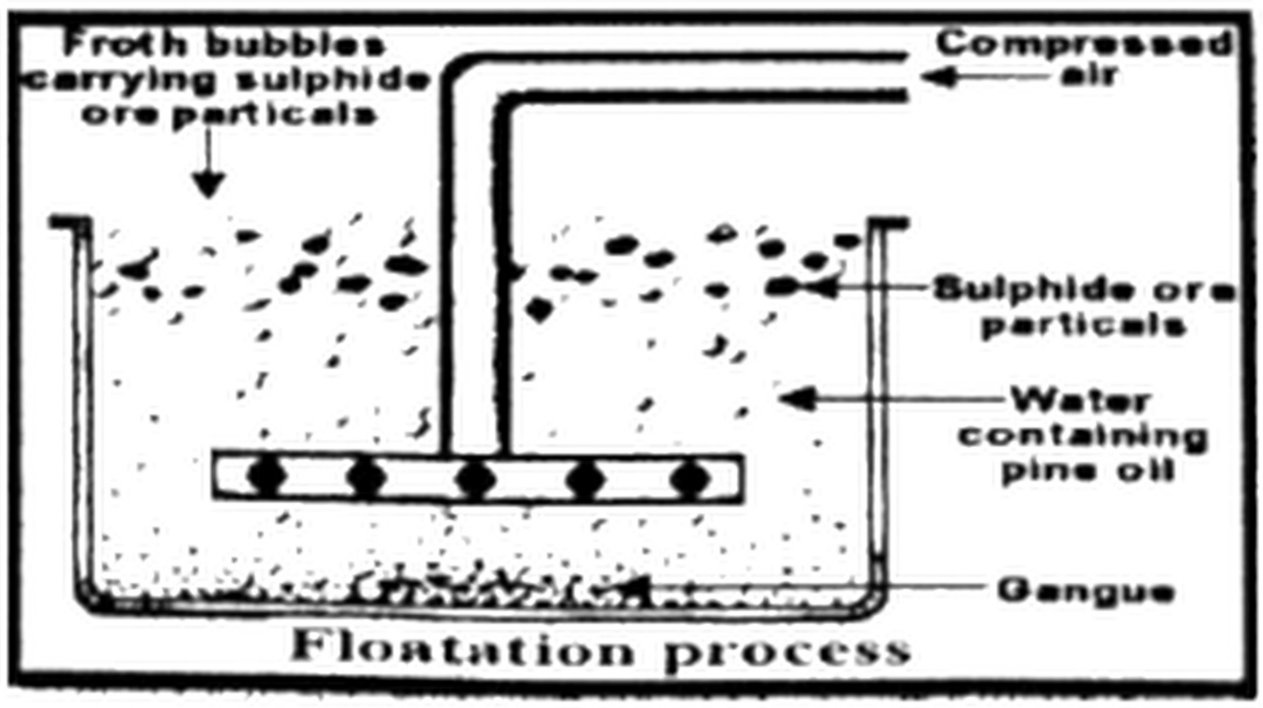
Ans: when large density differences exist between ore and impurities, a cyclone separator is used. In this method air under high pressure is known blown through pulverized ore. The lighter gangue is blown away through the top. But the dense mineral rich particles hit the walls by centrifugal force. They fall down the funnel.



Cyclone Separator

Q6. Explain the process of flotation process.

Ans: Pulverized ore is fed into a tank containing water and an oil-detergent mixture. The mixture is agitated with air. Detergents wet the mineral particles but not the silicate gangue. The mineral particles rise to the top of the mixture as a forth, form where they are skimmed off. Particles of the gangue fall down to the bottom the copper ore is concentrated generally by floating process.

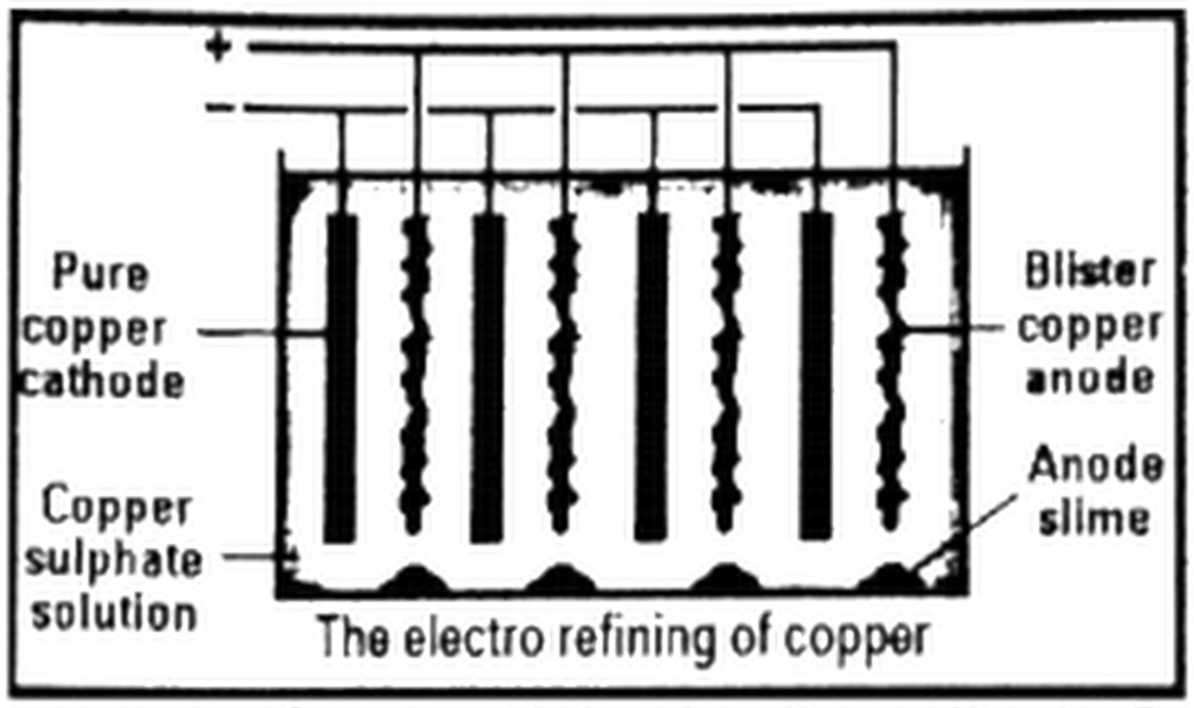


Floatation process

Q7. Explain refining or purification of copper metal?

Ans: Electro-refining of copper metal:

An electrolytic cell is used in electro-refining, in which impure metal such as



The electro refining of copper

the anode and a sample of pure metal act as the cathode. For example, electrolytic refining of copper is carried out in an electrolytic tank containing acidified copper sulphate solution as electrolyte. Impure slabs of copper act as anode and pure copper sheets as cathode.

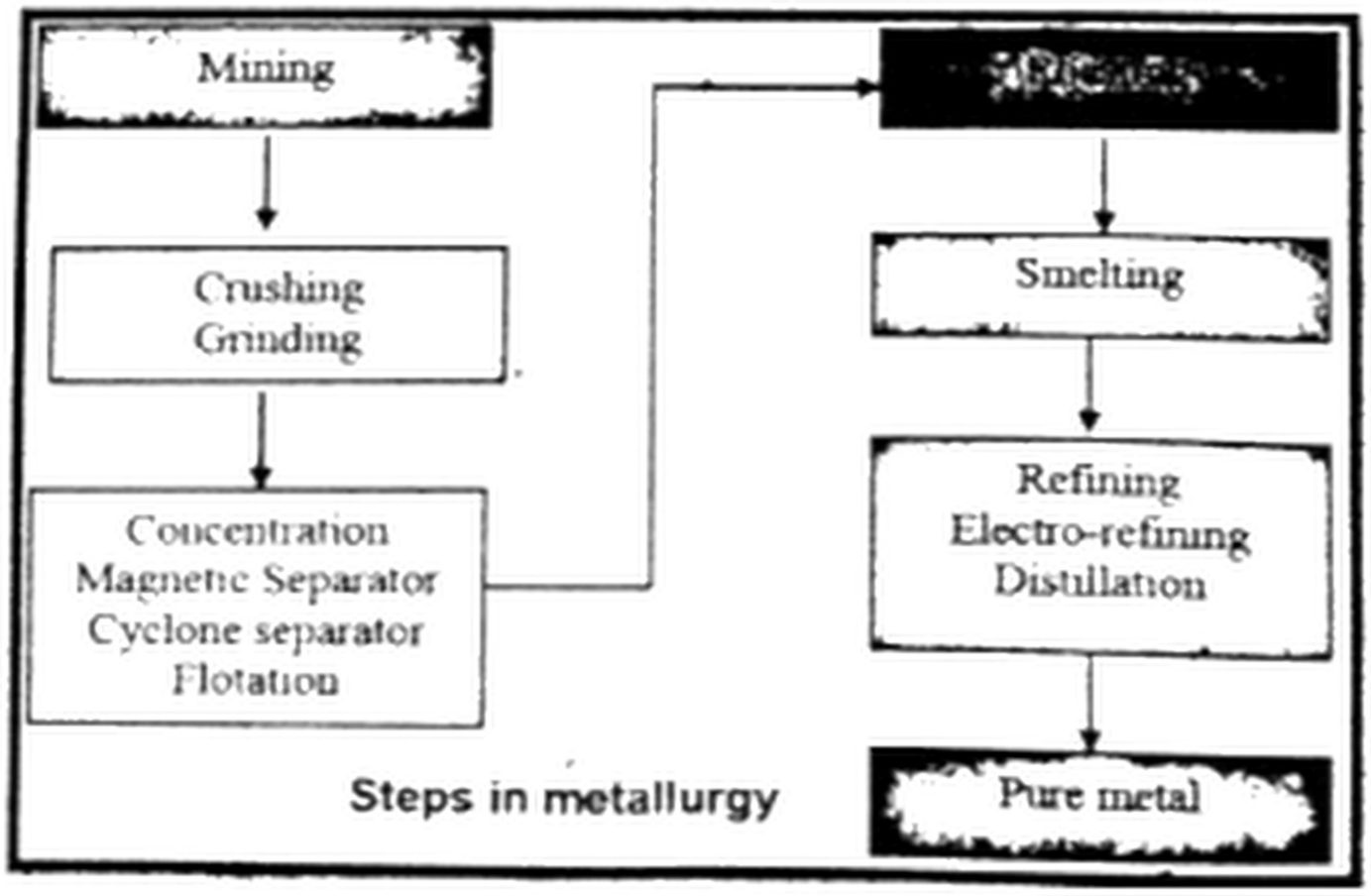
On passing electric current through the solution, impure copper dissolves forming Cu^{+2} ions gain electrons at cathode and from Cu atoms, which are deposited on the cathode. In this way pure copper is collected at cathode. The impurities like Au and Ag fall off the anode as anode mud.

Anode Reaction: $Cu_{(s)} \rightarrow Cu^{+2}_{(aq)} + 2e^-$

Cathode Reaction: $Cu^{+2}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

Q8. Explain with the help of flow chart steps in metallurgy?

Ans: Steps in metallurgy:



Steps in metallurgy

Self-Assessment Exercise 16.1

1. List important ores of iron, copper, zinc and mercury.
2. List out basic metallurgical operations.
3. List main processes used to concentrate the ore.
4. Write names of method used in the extraction of a metal from its concentrated ores.
5. List methods used to purify metals.

Solution:

1. List important ores of iron, copper, zinc and mercury.

Metal	Name of ore	Formula
Iron	Haematite	Fe_2O_3
Iron	Magnesite	Fe_3O_4
Copper	Chalcopyrite	$CuFeS_2$
Zinc	Zinc blende	ZnS
Mercury	Cinnabar	HgS

2. List out basic metallurgical operations.

Basic Metallurgical Operations:

The main steps in process are:

i. Crushing, grinding or pulverizing of the ore
ii. Concentration of the ore
iii. Extraction of metal
iv. Refining of metal

3. List main processes used to concentrate the ore.

a) Magnetic separation
b) Cyclone separation
c) Flotation process

4. Write names of method used in the extraction of a metal from its concentrated ores.

i. Roasting **ii.** Smelting **iii.** Refining

1. List methods used to purify metals.

i. Electro-refining **ii. Distillation**

OR (Second Answer)

Refining of metals means purification of metals.

i. Distillation:

Volatile meals like zinc and mercury are purified by this method. The non-volatile impurities are left behind in the retort.

ii. Liquidation:

metal melts and flows down, leaving behind the infusible impurities which remain sticking to the floor of the hearth.

iii. Poling:

Some impurities have greater affinity for oxygen than for the metal. When the molten metal is stirred with green wood poles, the impurities come to the surface, get oxidized and form a scum which can be removed. Wood gases (hydrocarbons from wood) reduce any oxide of the metal back to the metal. Cooper and tin are purified by this process.

Q9. Outline basic reactions of Solvay process.

Ans: Basic Reactions:

Solvay process consist of following steps

i. Preparation of ammonical brine:

Ammonical brine is prepared by dissolving ammonia gas in brine. Ammonical brine is fed into the carbonating tower.

ii. Carbonation:

In the carbonating tower, carbon dioxide is passed through ammonical brine. Following reaction takes place in it.

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

$$NH_4HCO_{3\,(aq)} + NaCl_{\,(aq)} \xrightarrow{15^\circ C} NaHCO_{3\,(s)} + NH_4Cl_{\,(aq)}$$

In the lower compartments of carbonating tower, the temperature of the mixture is lowered to 15°C. At this temperature, $NaHCO_3$ precipitates out.

iii. Filtration:

Precipitates of $NaHCO_3$ are separated from the milky solution by filtration. It is used as baking soda.

Sodium hydrogen carbonate is heated to get sodium carbonate

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

Carbon dioxide released is re-cycled in the process.

v. Preparation of carbon dioxide and slaked lime:

Carbon dioxide is produced by heating limestone in a kiln.

$$CaCO_{3\,(l)} \xrightarrow{heat} CaO_{\,(s)} + CO_{2\,(g)}$$

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

$$CaO_{\,(s)} + H_2O_{\,(l)} \rightarrow Ca(OH)_2$$

Slaked lime is pumped to the ammonia recovery tower.

vi. Recovery of ammonia:

Solution contain ammonium chloride produced in the carbonation tower is heated with slaked lime.

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

Almost all the ammonia is recovered in this process. It is reused in the process.

Q10. List the advantages of Solvay process.

Ans: Advantages of Solvay process:

i. It is a cheap process. The raw materials are cheap and easily available.

ii. It is a pollution free process. No harmful products are produced.

iii. It consumes less fuel. This is because there is no solution to be evaporated.

iv. Carbon dioxide and ammonia are recovered are re-used in the process.

v. It produces pure $NaHCO_3$ and Na_2CO_3.

Self-Assessment Exercise 16.2

2. **Outline the basic reactions of Solvay process.**

3. **List out main steps of Solvay process.**

Solution:

1. Make a list of raw materials of Solvay process.

Raw Materials:

Commercially, sodium carbonate is manufactured in a continuous process that uses:

a) Ammonia

b) Brine (concentrated sodium chloride solution)

c) Lime stone as a source of carbon dioxide and slaked lime, $Ca(OH)_2$

2. Outline the basic reactions of Solvay process.

See Q # 7 from Review Questions (Exercise)

3. List out main steps of Solvay process.

i. Preparation of ammonical brine

ii. Carbonation

iii. Filtration

iv. Calcinations

v. Preparation of carbon dioxide and slaked lime.

vi. Recovery of ammonia

Q11. Why fertilizers are added to the soil?

Ans: Importance of fertilizers:

Crops take nutrients from the soil, and these must be replaced before the next crop is sown.

Fertilizers are the compounds which are put in the soil to provide elements essential for plant's life. They are added to the soil to make up the deficiency caused by the previous crops.

Ans: Classification of fertilizers:

Fertilizers are classified into two categories:

1. Natural fertilizers:

Natural fertilizers or manures derived from animals and human wastes.

2. Synthetic fertilizers:

Synthetic fertilizers i.e. urea $CO(NH_2)_2$, ammonium sulphate $(NH_4)_2SO_4$, ammonium phosphate $(NH_4)_3PO_4$, calcium super phosphate $Ca(H_2PO_4)_2$ and di-ammonium phosphate $(NH_4)_2HPO_4$.

Q13. Why urea is one of the widely used fertilizer?

Ans: Urea is one of the widely used fertilizer because of the following qualities:

i) Percentage of nitrogen is highest among all the synthetic nitrogen fertilizers i.e. 46%.

ii) It does not affect the texture of the soil.

iii) In the soil it hydrolyses quickly to ammonium carbamate which eventually changes into NH_3 which decomposes into N_2 and H_2. Nitrogen is the main constituent of proteins; it is required by the stems and leaves during the early stages of the plant development.
It imports green colour to the leaves and increases the yield and quality of the crop.

Q14. Make a list of raw materials for manufacture of urea?

Ans: The raw materials for the manufacture of urea are:

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

Manufacturing of urea consists of following steps.

i. Reaction between NH_3 and CO_2 to form ammonium carbamate.

$$NH_{3(g)} + CO_{2(g)} \rightarrow NH_2COONH_4$$

ii. Distillation of ammonium carbamate.

iii. Evaporation of liquid urea and its granulation.

The urea solution is concentrated in vacuum evaporators. Which is the rapidly cooled and sent to the prilling tower. Urea prills thus produced are packed and then marketed.

Do you know?

% of Nitrogen in various fertilizers			
Fertilizers	**Formula**	**Molecular mass**	**% of Nitrogen**
Ammonium sulphate	$(NH_4)_2SO_4$	132	21.2
Ammonium nitrate	NH_4NO_3	80	35.0
Urea	NH_2CONH_2	60	46.6

Self-Assessment Exercise 16.3

1. **Calculate percentage of nitrogen in urea.**
2. **Outline the basic reactions that take place in the synthesis of urea.**
3. **What happens when ammonium carbamate is distilled with steam?**

Solution:

1. Calculate percentage of nitrogen in urea.

Molecular mass of urea = NH_2CONH_2

$= 14 + 2 \times 1 + 12 + 16 + 14 + 2 \times 1 = 60$ g

$\% \text{ of } N = \frac{mass\ of\ nitrogen \times 100}{}$

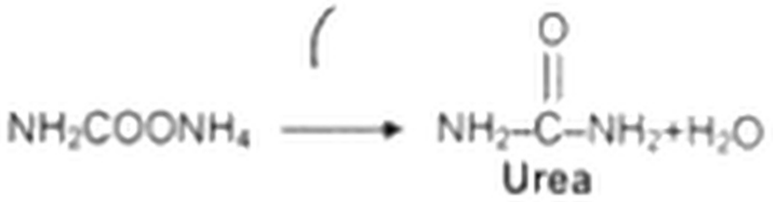
$$\% \text{ of } N = \frac{28 \times 100}{60} = \frac{2800}{60} = 46.6\%$$

2. Outline the basic reactions that take place in the synthesis of urea.

i. Reaction between NH_3 and CO_2 to form ammonium carbamate.

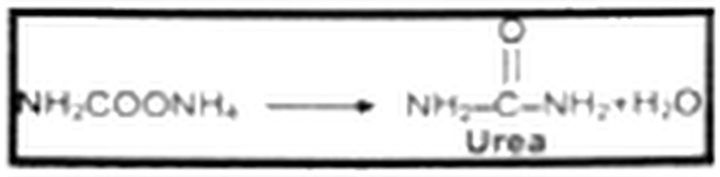
1. $NH_{3\,(l)} + CO_{2\,(l)} \rightarrow NH_2COONH_4$

ii. Distillation of ammonium carbamate.



3. What happens when ammonium carbamate is distilled with steam?

Distillation of ammonium carbamate.



Society, Technology and Science

1. Compare natural fertilizers VS synthetic fertilizers.

Natural fertilizers are better than synthetic fertilizers. Natural fertilizers are insoluble in water. They decompose slowly and gradually by bacteria and liberate useful water-soluble nutrients for plants. They do not contain toxic chemicals and hence do not damage the soil crops and plants.

On the other hand, synthetic fertilizers are soluble in water. When more fertilizer is applied than the soil can absorb, rain washes off the excess fertilizer. This is not only uneconomical but also hazardous to environment. The dissolved nutrients flow into streams, lakes and rivers and contribute in the eutrophication of their wastes. It results in over growth of water plants, algae and bad odour in these waters. A bloom of algae can spread across the surface, blocking light for other plant life in the water. When plants and algae die, bacteria multiply

the water. Without oxygen, fish die affecting the whole ecosystem. Nitrates in drinking water cause stomach cancer.

2. People have been preparing common chemical such as acids, alkalis, soaps, baking soda, soda ash, caustic soda etc. since centuries. But the use of technology has not increased production of chemicals but also improved the quality as well.

For instance, soda ash and baking soda are produced chemically by Solvay process, which is a continuous process. Soda is not handled until it is packed. Carbon dioxide and ammonia are recovered almost 100%. At the same time process is pollution free.

Q15. Define petroleum:

Ans: Petroleum:

The name petroleum is derived from Latin words petra (rock) and oleum (oil). It is also called as crude oil. Petroleum and crude oil is thick dark liquid composed mostly of hydrocarbons.

Q16. Define natural gas:

Ans: Natural gas:

Natural gas, usually associated with petroleum deposits, consists mostly of methane. It also contains significant amounts of ethane, propane and butane.

Q17. Describe briefly the fractional distillation of petroleum.

OR

How important fractions of petroleum are separated?

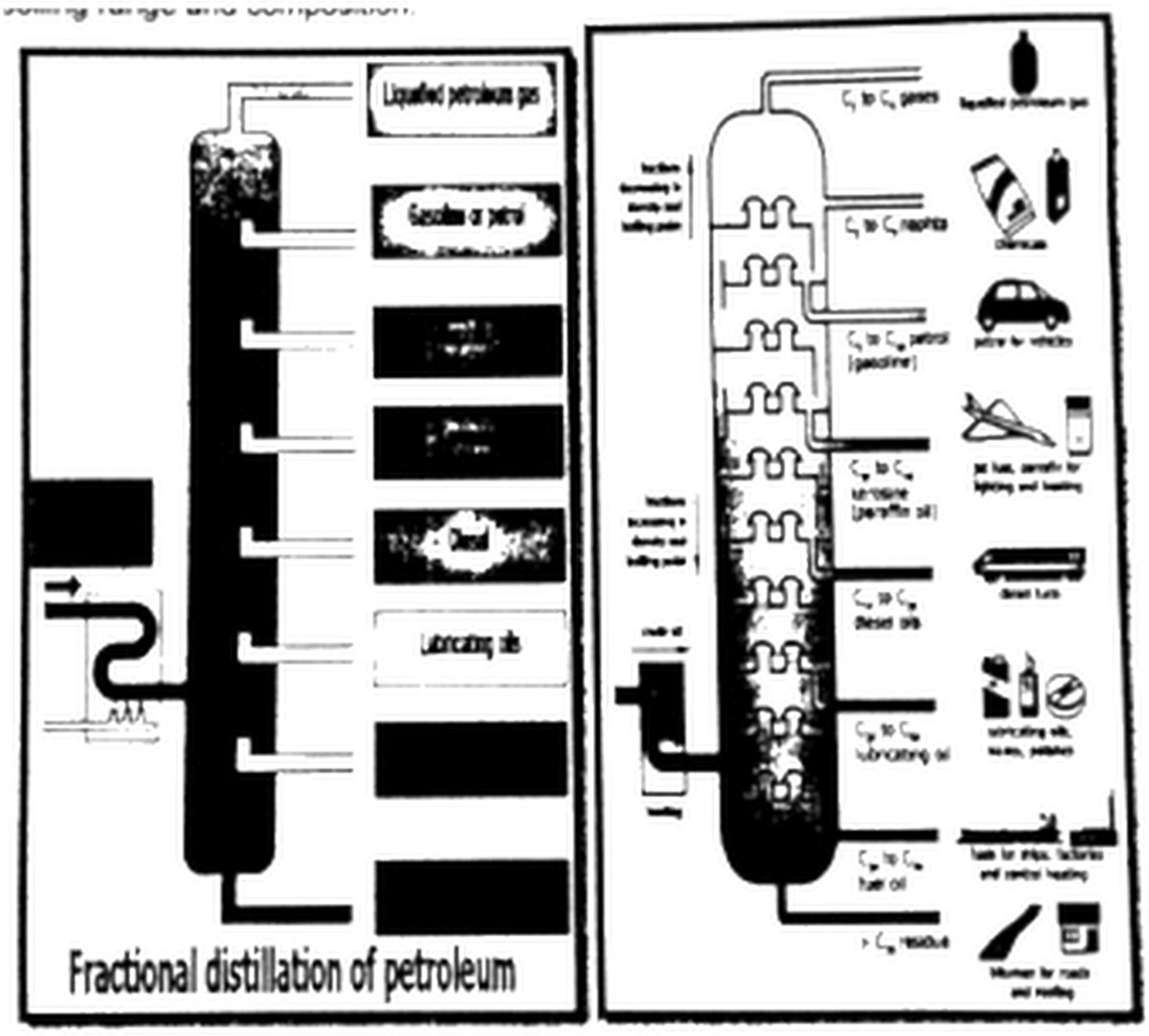
Ans: Refining:

The conversion of crude oil into useful product is called refining. These useful products are called fractions. Each fraction consists of a mixture of hydrocarbons which boil in a certain range of temperature.

Fraction distillation:

Petroleum is refined by fractional distillation in a tall fractionating tower. The crude oil is heated up to 400°C under high pressure in a furnace. Then it is passed through the factional distillation column. Its vapours rise through the column.

As hot vapour move up, they condense according to their boiling points into various fractions. Compounds with highest boiling points condense first near



the bottom. Compounds with lowest boiling point last near the top. Compounds which do not boil, collects at the bottom as residue. In this way vapour condense gradually at different levels according to their boiling points. Therefore, crude oil is separated into various fractions. Each fraction has its own specific boiling range and composition.

Ans: Fractions of petroleum and their uses:

Fractions	Number of carbon atoms per molecule	Boiling point at ℃	Important uses
Liquefied petroleum gas (LPG)	1-4	Below 20	Cylinder gas for cooking
Petrol	5-10	35-70	Fuel for motor cars and vehicles
Naptha	8-12	70-120	Chemical feedstock for making drugs, plastics and other chemicals
Kerosene	10-16	170-250	Fuel for jet planes, fuel for heating, lighting and cooking
Diesel	14-20	270-340	Fuel for buses, truck and trains
Lubricating oil	20-50	350-500	Lubricants for machines and engines, waxes and polishes
Fuel oil	50-70	500-600	Fuel for power station, factories and ships
Bitumen	More than 70	More than 500	Paving roads and making roofing materials

Self-assessment exercise 16.4

1. Define petroleum.
2. List name of fractions obtained by fractional distillation of petroleum.
3. List one use of each petroleum fraction.
4. How is petroleum obtained?

Solution:

1. Define petroleum.

Petroleum:

The name petroleum is derived from Latin words petra (rock) and oleum (oil). It is also called as crude oil. Petroleum and crude oil are thick dark liquid composed mostly of hydrocarbons.

2. List name of fractions obtained by fractional distillation of petroleum.

See Q # 18 from Notes.

3. List one use of each petroleum fraction.

See Q # 18 from Notes.

4. How is petroleum obtained?

Oil companies obtain petroleum and crude oil by discovering oil by reservoirs and establishing oil rigs. The oil rigs drill into the reservoirs and extract petroleum, which refineries process into products such as gasoline, diesel fuel, asphalt and petroleum jelly.

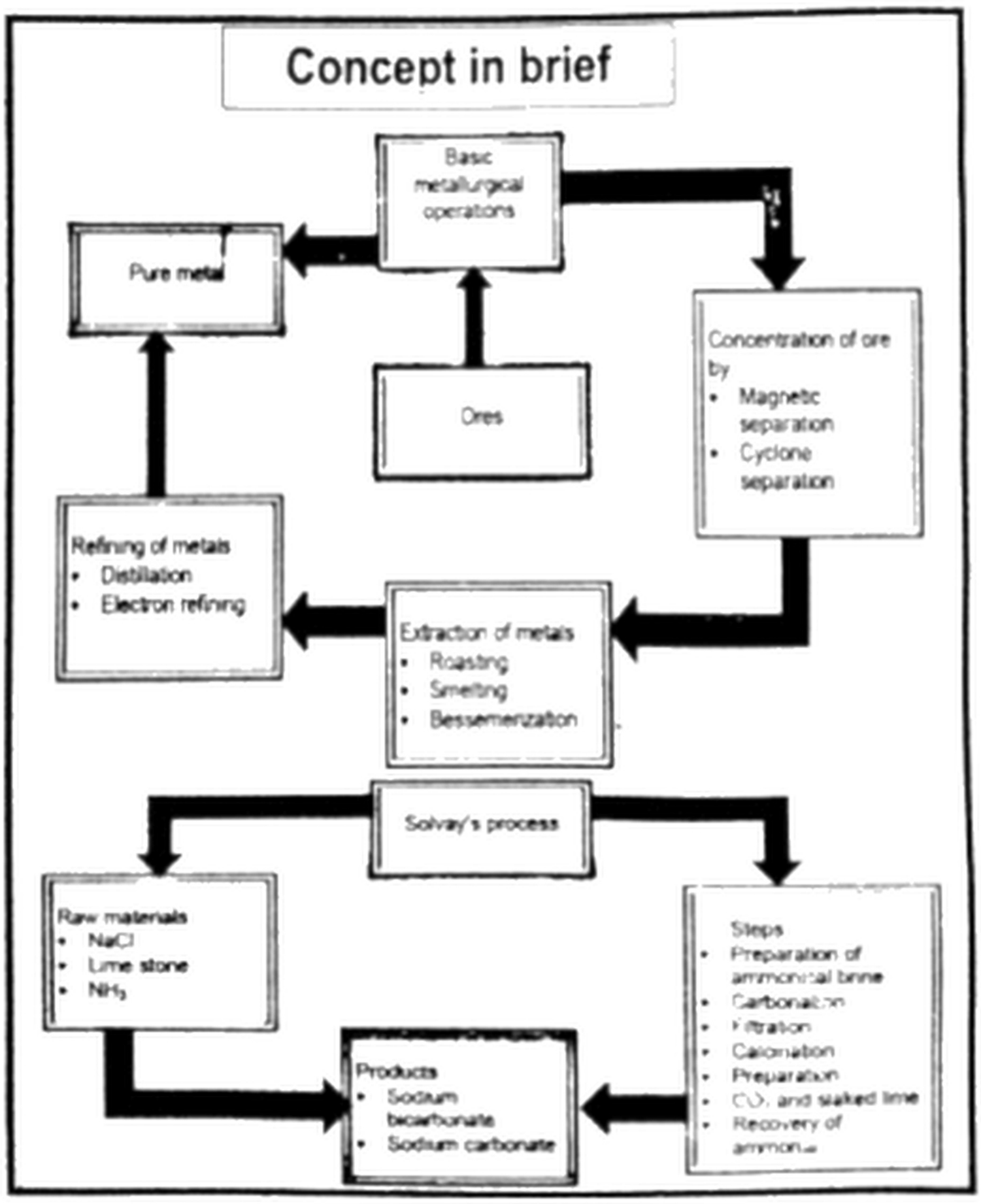
Society, Technology and Science

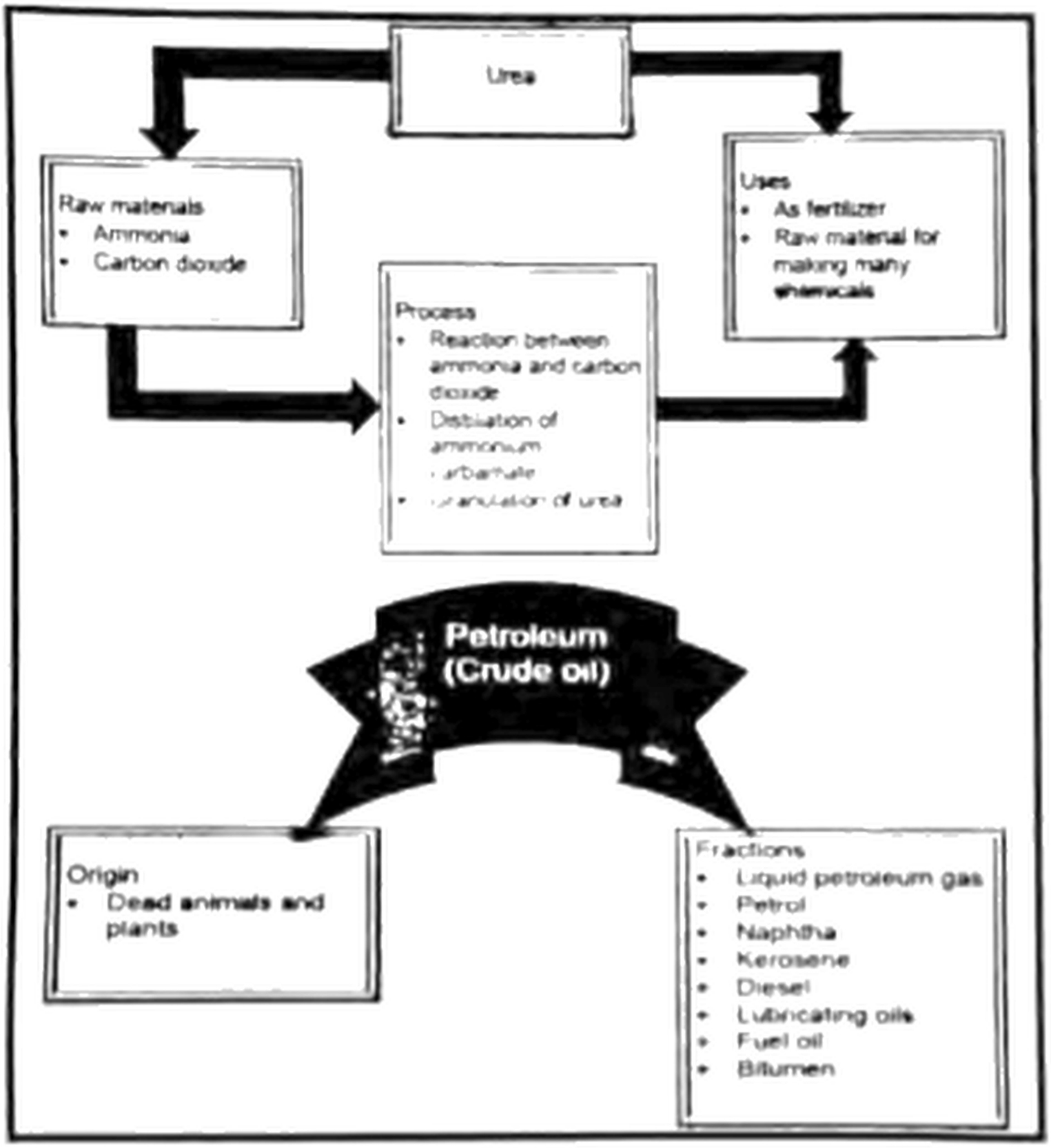
Wood, oil or electric fires required different techniques to put them out. Wood fire is generally extinguished by throwing water on it. Water has high heat of vaporization. So, it absorbs considerable amount of heat from the fire before it vaporizes. So, it gradually cools burning wood and extinguishers fire. Oil fire, on the other hand cannot be put off by water. This is because oil and water do not mix. At the same time oil is lighter than water. It floats over water. The fire also spreads with flowing water. Water cannot cut of contact between burning oil and oxygen. Oil fire is usually put off by throwing sand on it. Electric fires can only be put out by fire extinguishers.

The modern application of chemical technology is a big business. Chemical firm spent billions of dollars on new machines, lifesavings drugs, effective pesticides, germicides, fungicides, synthetics fertilizers, paints, cosmetics, artificial flavors, sweeteners, etc. These chemicals have raised our standard of living. However, besides benefits, these substances have some drawbacks and risks. It is the job of sales officers to keep you aware of such drawbacks besides explaining benefits. It is important to express benefits of chemicals in a way that everyone can

understand in order to share information he needs to develop good communication skills to promote chemical sales.

Concept in brief




Urea
Raw materials
• Ammonia
• Carbon dioxide
Process
• Reaction between ammonia and carbon dioxide
• Distillation of ammonium
• arbamate
• ranulation of urea
Uses
• As fertilizer
• Raw material for making many chemicals
Petroleum (Crude oil)
Origin
• Dead animals and plants
Fractions
• Liquid petroleum gas
• Petrol
• Naphtha
• Kerosene
• Diesel
• Lubricating oils
• Fuel oil
• Bitumen