

CHAPTER # 16

CHEMICAL INDUSTRIES

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

Ans: Sodium Carbonate Decahydrate $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

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	Magnetite	Fe_3O_4
Copper	Chalcopyrite	CuFeS_2
Aluminium	Bauxite	$\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$
Sodium	Halite	NaCl
Lead	Galena	PbS
Zinc	Zinc blende	ZnS
Mercury	Cinnabar	HgS
Chromium	Chromite	$\text{FeO} \cdot \text{Cr}_2\text{O}_3$
Tin	Cassiterite	SnO_2
Silicon	Silica	SiO_2

Q3. Define mineral, gangue and ore.

Ans: Mineral:

The naturally occurring metallic compounds are called minerals.

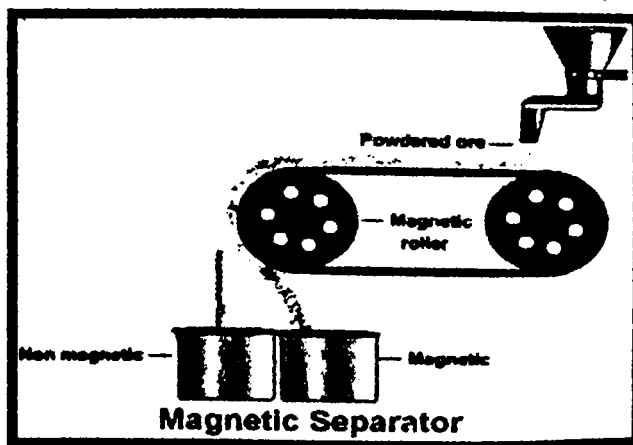
Gangue:

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.

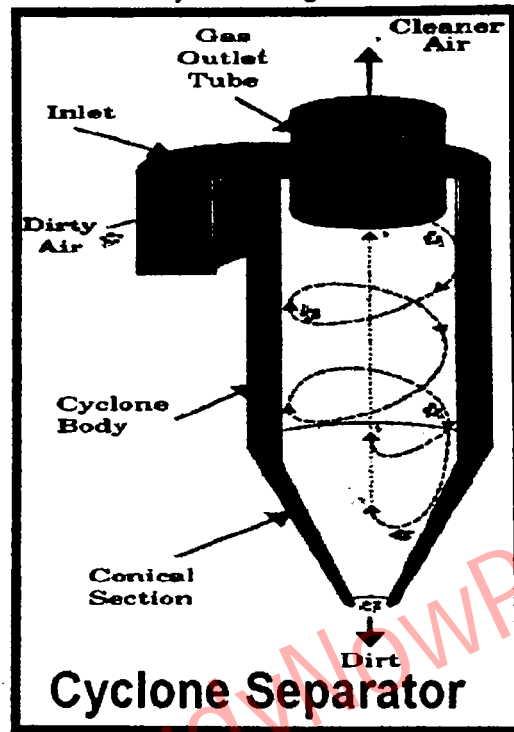
Q4. Explain the process of Magnetic Separation.

Ans: For magnetic ore, a magnet is used to remove mineral, leaving the gangue behind. The powdered 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.

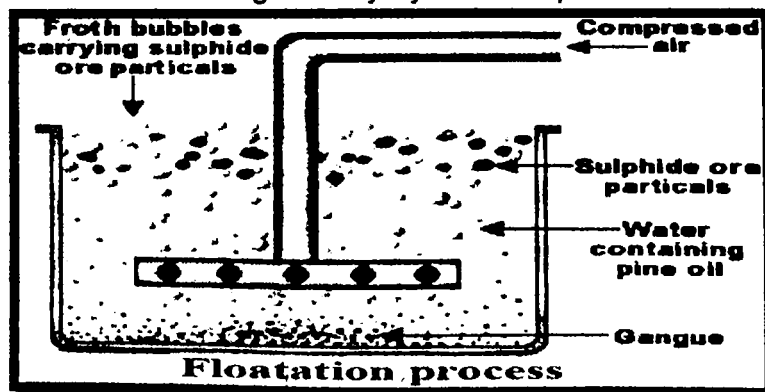


Q5. Explain the process of Cyclone Separation.

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

**Q6. Explain the process of Flotation Process.**

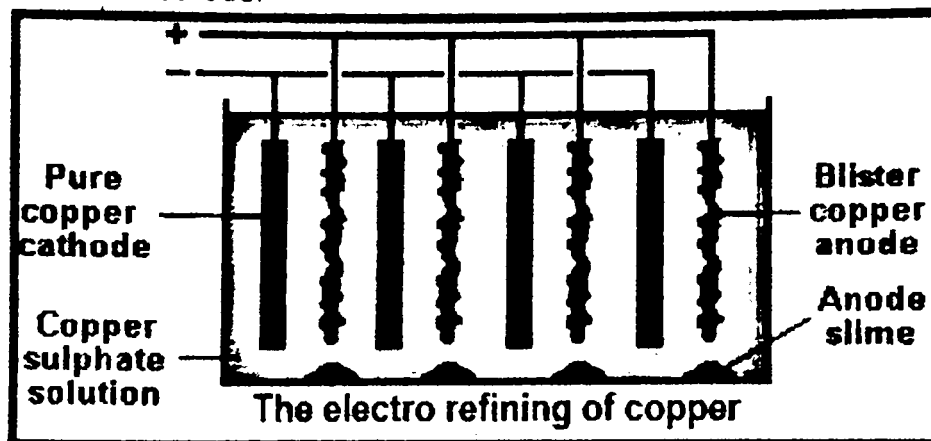
Ans: Pulverized ore is fed into a tank containing water and an oil-detergent mixture. The mixture is agitated with air. Detergents wet the mineral particles but not the silicate gangue. The mineral particles rise to the top of the mixture as a froth, from where they are skimmed off. Particles of the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



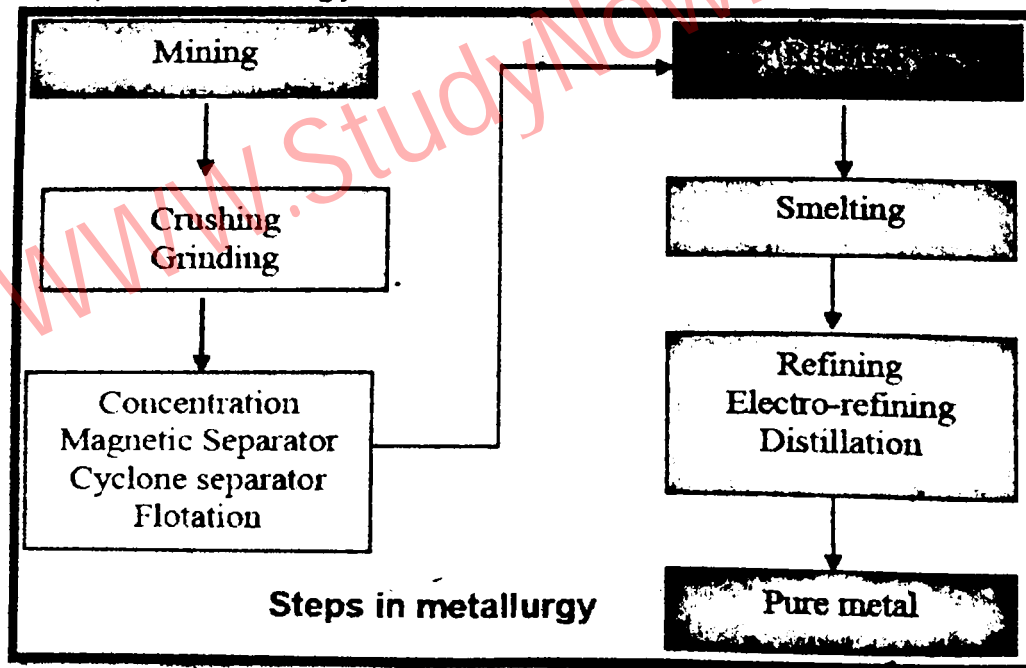
On passing electric current through the solution, impure copper dissolves forming Cu^{+2} ions. These Cu^{+2} ions gain electrons at cathode and form Cu atoms, which are deposited on the cathode. In this way pure copper is collected at cathode. The impurities like Au and Ag fall off the anode as anode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

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

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

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

Ans: 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 methods 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	Magnetite	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 methods used in the extraction of a metal from its concentrated ores.

- i. Roasting
- ii. smelting
- iii. refining

5. 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. Liquation:

The method is used for easily fusible like bismuth, tin and lead. The crude metal is placed on the sloping hearth of a furnace and heated gently when the 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 oxidised and form a scum which can be removed. Wood gases (hydrocarbons from wood) reduce any oxide of the metal back to the metal. Copper and tin are purified by this process.

Q9. Outline basic reactions of Solvay process.**Ans: Basic Reactions:**

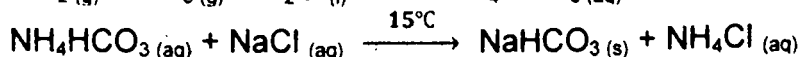
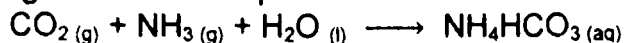
Solvay process consist of following steps

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.



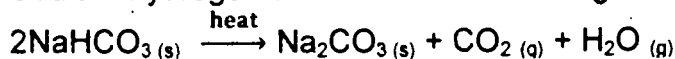
In the lower compartments of carbonating tower, the temperature of the mixture is lowered to 15 °C. At this temperature, NaHCO₃ precipitates out.

iii) Filtration:

Precipitates of NaHCO₃ are separated from the milky solution by filtration. It is used as baking soda.

iv) Calcinations:

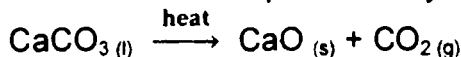
Sodium hydrogen carbonate is heated to get sodium carbonate



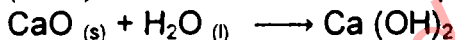
Carbon dioxide released is re-cycled in the process.

v) Preparation of carbon dioxide and slaked lime.

Carbon dioxide is produced by heating limestone in a kiln.



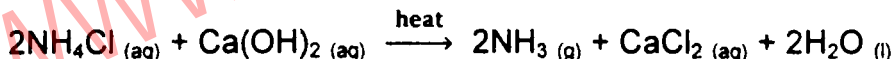
Carbon dioxide is fed into the carbonating tower from the top. Equal amounts of lime (CaO) and water are mixed to produce slaked lime, Ca(OH)₂



Slaked lime is pumped to the ammonia recovery tower.

vi) Recovery of ammonia:

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



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 and re-used in the process.
- v) It produces pure NaHCO₃ and Na₂CO₃

Self-Assessment Exercise 16.2

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

Q12. List the classification of fertilizers?

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 $\text{CO(NH}_2)_2$, ammonium sulphate $(\text{NH}_4)_2\text{SO}_4$, ammonium phosphate $(\text{NH}_4)_3\text{PO}_4$, calcium super phosphate $\text{Ca(H}_2\text{PO}_4)_2$ and di-ammonium phosphate $(\text{NH}_4)_2\text{HPO}_4$.

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 imparts green colour to the leaves and increases the yield and quality of the crop.

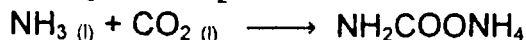
Q14. Make a list of raw materials for Manufacture of urea?

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

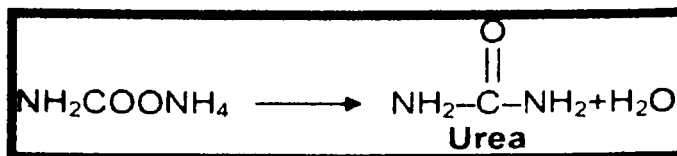
- i) Ammonia (NH_3)
- ii) Carbon dioxide (CO_2)

Manufacturing of urea consists of following steps.

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



- ii) Distillation of ammonium carbamate.



iii) Evaporation of liquid urea and its granulation.

The urea solution is concentrated in vacuum evaporators, which is then 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			
Fertilizer	Formula	Molecular mass	% age of Nitrogen
Ammonium sulphate	$(\text{NH}_4)_2\text{SO}_4$	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

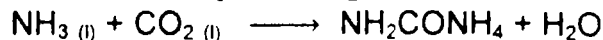
$$= 14 + 2 \times 1 + 12 + 16 + 14 + 2 \times 1 = 60 \text{ g}$$

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

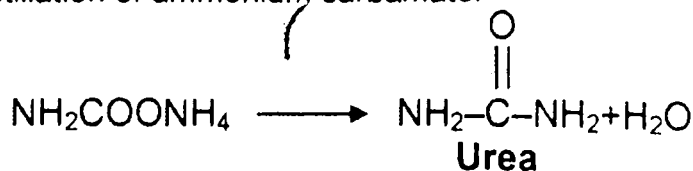
$$\% \text{ of N} = \frac{28 \times 100}{60} = \frac{2800}{60} = 46.6\%$$

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.

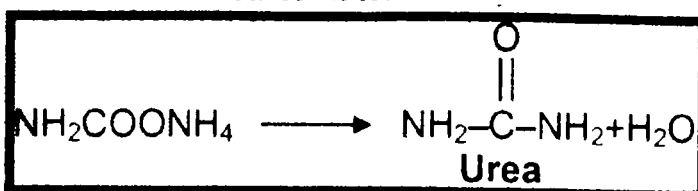


ii) Distillation of ammonium carbamate.



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 water soluble. 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 the environment. The dissolved nutrients flow into stream, lakes and rivers and contribute in the eutrophication of their waters. 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 rapidly with so much food available. They remove the dissolved oxygen in 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 only increased production of chemicals but improved quality as well.

For instance, soda ash and baking soda are produced commercially 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 or 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:

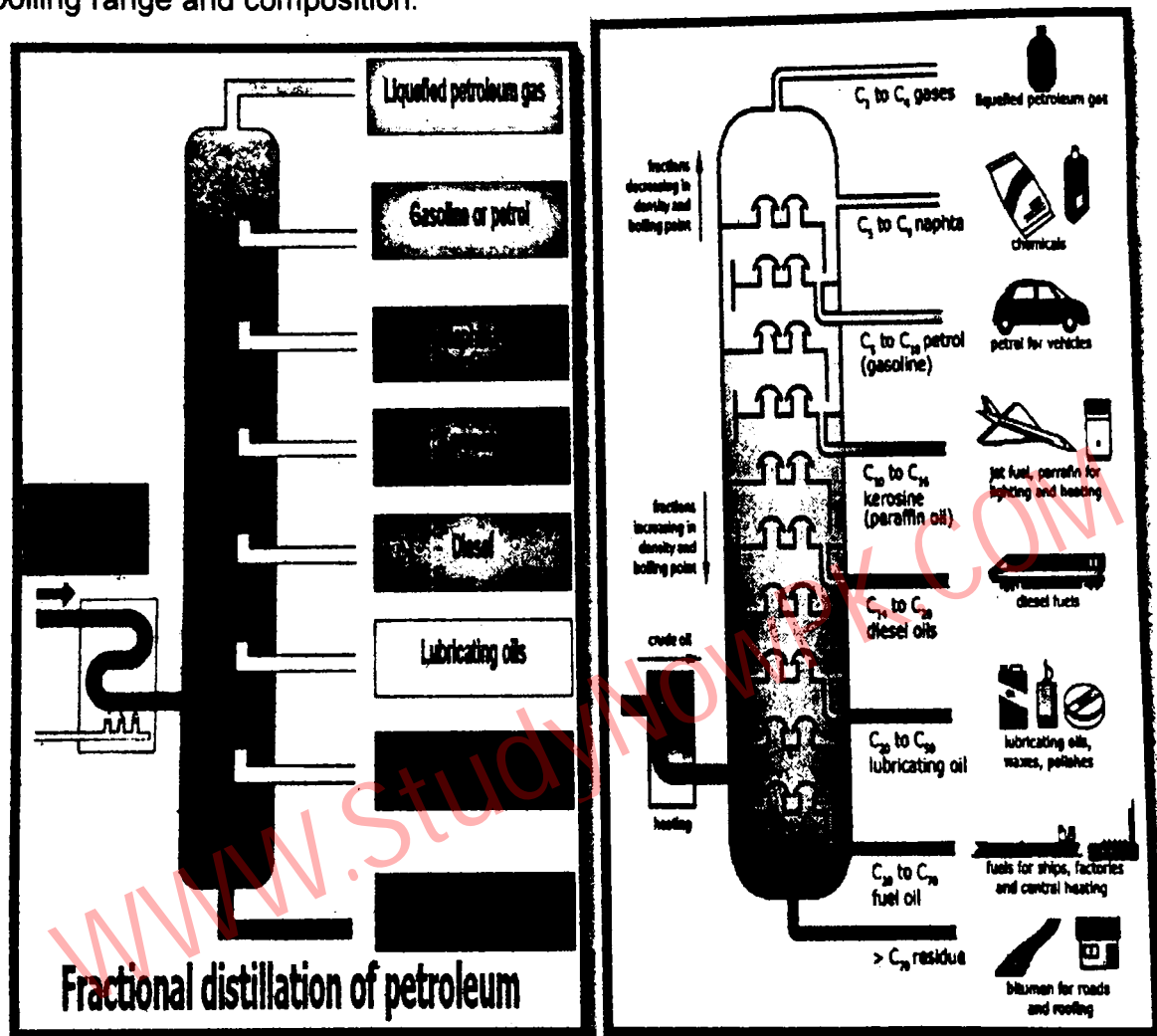
The conversion of crude oil into useful products is called **refining**. These useful products are called fractions. Each fraction consists of a mixture of hydrocarbons which boil in a certain range of temperature.

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 fractional 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, condense last near the top. Compounds which do not boil, collect 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.



Q18. Describe the physical properties and uses of petroleum fractions?

Ans: Fractions of petroleum and their uses:

Fraction	Number of carbon atoms per molecule	Boiling point °C	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
Naphtha	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 stations, 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 names of fractions obtained by the 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 or crude oil is thick dark liquid composed mostly of hydrocarbons.

2. List names of fractions obtained by the 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?

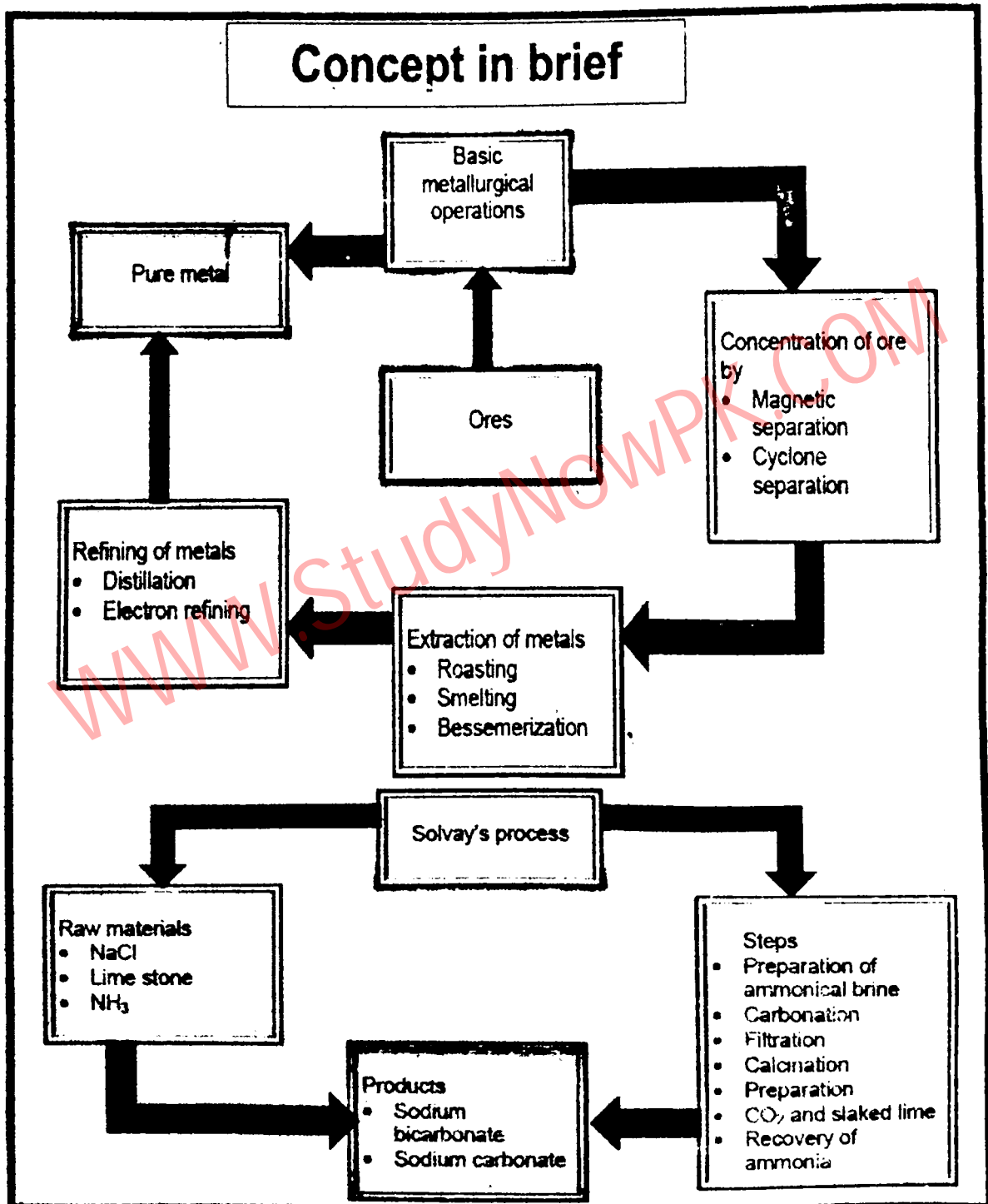
Oil companies obtain petroleum or crude oil by discovering oil reservoirs and establishing oil rigs. The oil rigs drill into the reservoirs and extract petroleum, which refineries process into products such as gasoline, diesel fuel, asphalt and petroleum jelly.

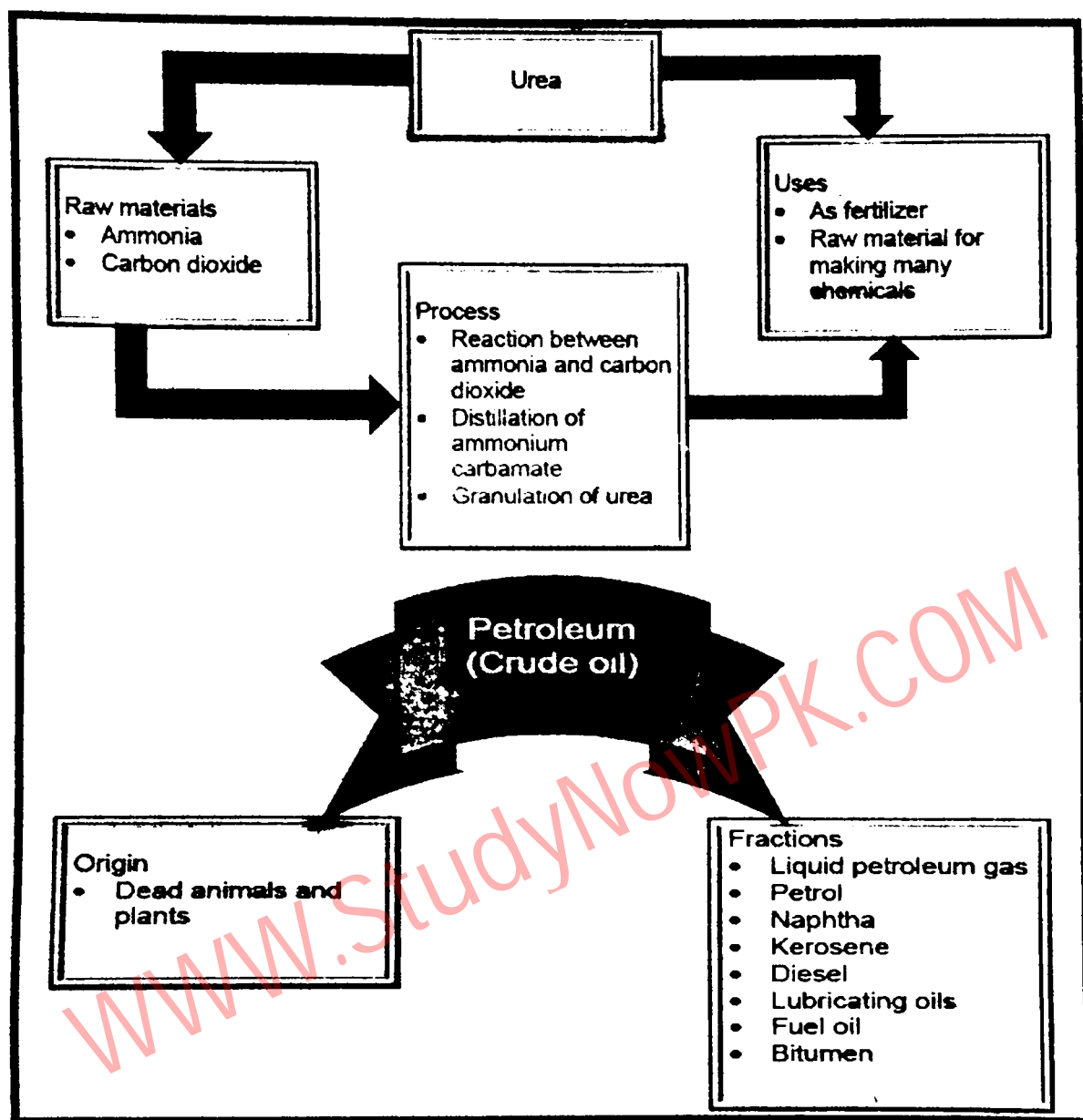
Society, Technology and Science

1. 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 extinguishes 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.

2. The modern application of chemical technology is a big business. Chemical firms spent billions of dollars on chemical research and development. The industrial use of chemistry brings us new medicines, lifesaving drugs, effective pesticides, germicides, fungicides, synthetic 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 officer 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.





KEY POINTS

- i. **Minerals:** The naturally occurring metallic compounds are called minerals.
- ii. **Ore:** An ore is a solid deposit containing a sufficiently high percentage of a mineral to make extraction of metals economically feasible.
- iii. **Metallurgy:** The process of separating a metal from its ores and preparing it for use is known as metallurgy.
- iv. **Basic metallurgical operations:** Basic metallurgical operations are crushing, grinding, concentration, extraction and refining.
- v. **Roasting:** The process of converting a mineral into oxide by heating in the air at temperature below their melting point is called roasting.

- vi. **Smelting:** The method to reduce metal ions to free metal is called smelting.
Blister copper: Copper obtained from Bessemer converter is called blister copper. It is 97% 99% pure copper.
- vii. Metals with relatively low melting points such as *As* and *Hg* are refined by distillation.
- viii. **Classification of fertilizers:** Fertilizers are classified into two categories
 a) Natural fertilizers or manures
 b) Synthetic fertilizers
- ix. **Fossil fuels:** Coal, petroleum and natural gas are called fossil fuels, because they were formed underground from the remains of once-living organisms.
- x. **Natural gas:** Natural gas consists mostly of methane. It also contains significant amounts of ethane, propane and butane.
- xi. **Refining:** The conversion of crude oil into useful products is called refining.
- xii. Each petroleum fraction has its own specific boiling range and composition.

REVIEW QUESTIONS

1. **Select the correct answer**
- i) **The naturally occurring metallic compounds are called as**
 A. ore
 B. gangue
 C. mineral
 D. rock
- ii) **The separation of minerals from gangue is called concentration. Which of the following methods is used for concentration?**
 A. smelting
 B. roasting
 C. refining
 D. flotation
- iii) **Which of the following steps is not used in the extraction process of metals**
 A. roasting
 B. smelting
 C. flotation
 D. bessemerization
- iv) **In electrolytic refining of copper, _____ is used as anode.**
 A. pure copper
 B. impure copper
 C. copper sulphate
 D. electrolytic tank
- v) **Which of the followings is not a raw material for the manufacture of soda ash.**
 A. ammonia
 B. carbon monoxide
 C. brine
 D. lime stone
- vi) **A mixture of Cu_2S and FeS called matte is produced in one of the metallurgical operations in the extraction of copper. The name of this operation is.**
 A. smelting
 B. roasting
 C. bessemerization
 D. electro-refining
- vii) **Chemical formula of slaked lime is**
 A. CaCO_3
 B. CaO
 C. Ca(OH)_2
 D. CaCl_2

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- vii) **Chemical formula of slaked lime is**
 A. CaCO_3
 B. CaO
 C. Ca(OH)_2
 D. CaCl_2

- viii) **Calcination is the process in which sodium hydrogen carbonate is heated to get sodium carbonate. Which is not obtained in this process?**
 A. CO_2 B. CO
 C. Na_2CO_3 D. H_2O
- ix) **Percentage of nitrogen in urea is**
 A. 35 B. 21.2
 C. 80 D. 46.6
- x) **What happens when ammonium carbamate is distilled with steam?**
 A. ammonia is produced B. carbon dioxide is released
 C. urea is produced D. urea solution is produced

Answers

i. C	ii. D	iii. C	iv. B	v. B
vi. B	vii. C	viii. B	ix. D	x. D

2. Give short answers.**i) How are urea prills produced?**

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

ii) What is slaked lime? How is it produced?

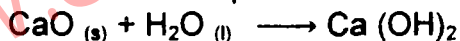
Ans: Slaked lime is Ca(OH)_2 .

Preparation of slaked lime:

Carbon dioxide is produced by heating limestone in a kiln.

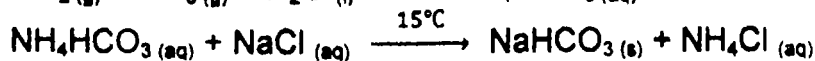
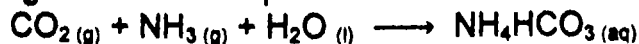


Carbon dioxide is fed into the carbonating tower from the top. Equal amounts of lime (CaO) and water are mixed to produce slaked lime, Ca(OH)_2 .

**iii) Write chemical reactions that take place during carbonation in Solvay process.****Ans: Carbonation:**

In the carbonating tower, carbon dioxide is passed through ammoniacal brine.

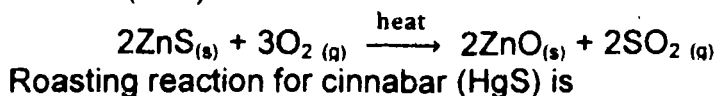
Following reaction takes place in it.

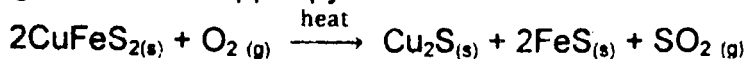
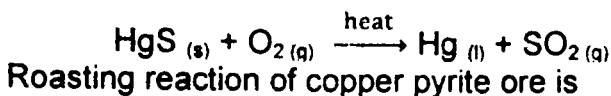


In the lower compartments of carbonating tower, the temperature of the mixture is lowered to 15°C . At this temperature, NaHCO_3 precipitates out.

iv) Explain the process "Roasting" with two examples.**Ans: Roasting:**

Some minerals are converted to oxide by heating in the air at temperature below their melting point. This process is called **roasting**. For example, the roasting for zinc blende (ZnS) is





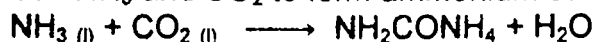
v) **Write chemical reactions that take place during urea formation.**

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

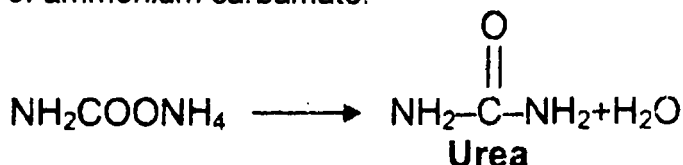
Manufacturing of urea consists of following steps.

i) Ammonia (NH₃) ii) Carbon dioxide (CO₂)

i) Reaction between NH₃ and CO₂ to form ammonium carbamate.



ii) Distillation of ammonium carbamate.



iii) Evaporation of liquid urea and its granulation.

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

3. Describe the following with an example

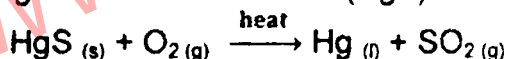
a) roasting b) smelting c) flotation

Ans: (a) **Roasting:**

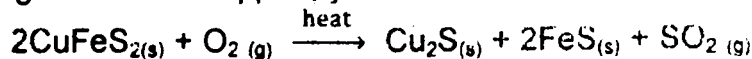
Some minerals are converted to oxide by heating in the air at temperature below their melting point. This process is called **roasting**. For example, the roasting for zinc blende (ZnS) is



Roasting reaction for cinnabar (HgS) is



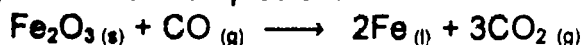
Roasting reaction of copper pyrite ore is



(b) **Smelting:**

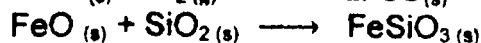
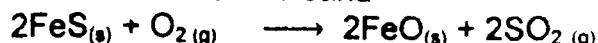
The method to reduce metal ions to free metal is called **smelting**.

The most common reducing agents are coke, carbon monoxide and hydrogen. Some examples are:



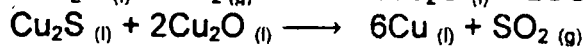
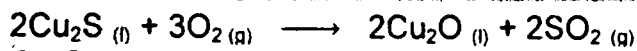
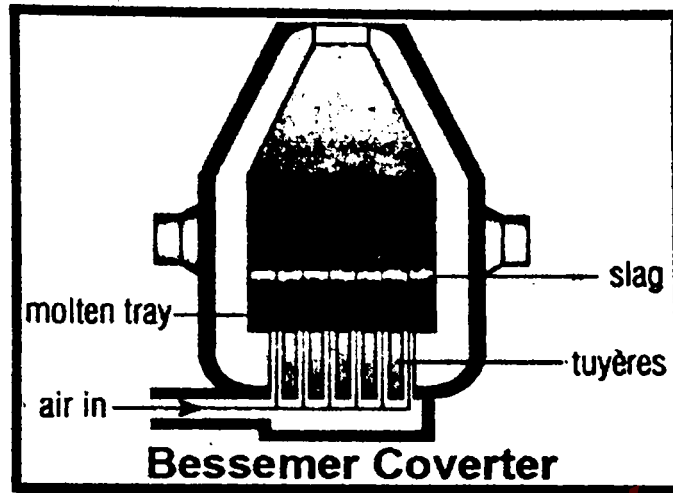
However, smelting of copper ore is done in two steps.

i) The roasted copper ore is heated with coke and sand at about 1100°C. The materials melt and separate into two layers. The bottom layer that contains mixture of Cu₂S and FeS is called matte. While the upper layer is a silicate slag formed by the reaction of FeO and sand



ii) Bessemerization:

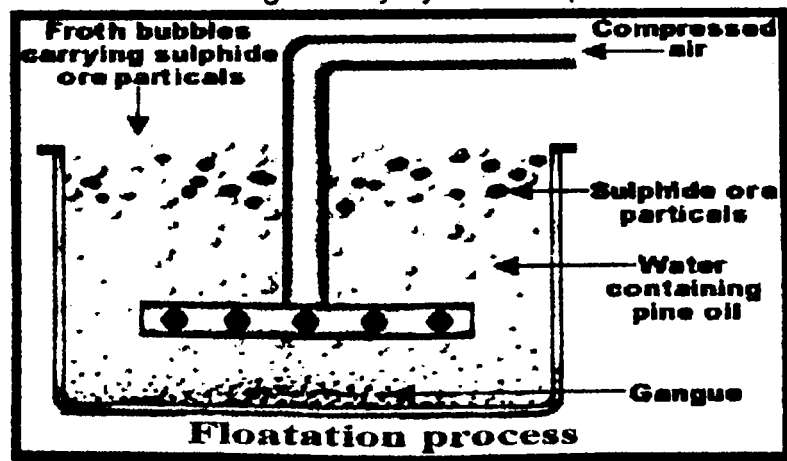
In this process air is blown through the molten copper matte in a Bessemer converter (Figure 16.4). Any remaining iron sulphide (FeS) is oxidized and removed as slag (FeSiO_3). In the final smelting step cuprous sulphide (Cu_2S) is oxidized to form cuprous oxide, which reacts with remaining cuprous sulphide to form metallic copper.



The product, called blister copper is about 97 to 99% pure Cu, with entrapped bubbles of $\text{SO}_{2(g)}$. Bessemerization is also used to convert pure iron into steel.

(c) Flotation Process:

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 froth, from where they are skimmed off. Particles of the gangue fall down to the bottom. The copper ore is concentrated generally by flotation process.

**4. Make a list of metallurgical operations.**

Ans: Metallurgy:

The process of separating a metal from its ore and preparing it for use is known as metallurgy.

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.

5. How was crude oil formed?

Ans: Origin/formation of Petroleum or crude oil:

It is believed that petroleum was formed from organisms that lived hundreds of millions of years ago. Plants and animals in the seas died. Their remains piled up. Layers of sand, rock and mud buried the dead organisms. Over time, in the absence of air, heat and pressure of sediments and bacterial effect changed the material into dark brownish viscous liquid called petroleum. It is also called crude oil. The gaseous products accumulated over the petroleum, is called as natural gas.

6. State five specific products made from crude oil.

Ans: Natural gas, Butane, Propane, Gasoline, Home heating oil, Plastics, Kerosene and jet fuel, Diesel.

7. Outline basic reactions of Solvay process.

Ans: Basic Reactions:

Solvay process consist of following steps

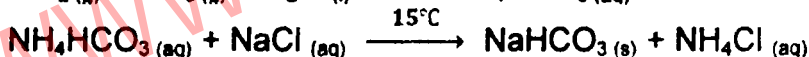
i) Preparation of ammonical brine:

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.



In the lower compartments of carbonating tower, the temperature of the mixture is lowered to 15 °C. At this temperature, NaHCO₃ precipitates out.

iii) Filtration:

Precipitates of NaHCO₃ are separated from the milky solution by filtration. It is used as baking soda.

iv) Calcinations:

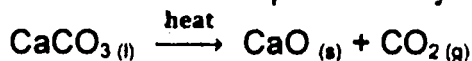
Sodium hydrogen carbonate is heated to get sodium carbonate



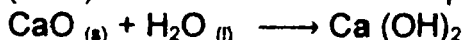
Carbon dioxide released is re-cycled in the process.

v) Preparation of carbon dioxide and slaked lime.

Carbon dioxide is produced by heating limestone in a kiln.



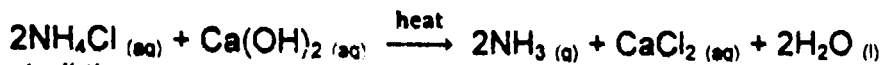
Carbon dioxide is fed into the carbonating tower from the top. Equal amounts of lime (CaO) and water are mixed to produce slaked lime, Ca(OH)₂



Slaked lime is pumped to the ammonia recovery tower.

vi) Recovery of ammonia:

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

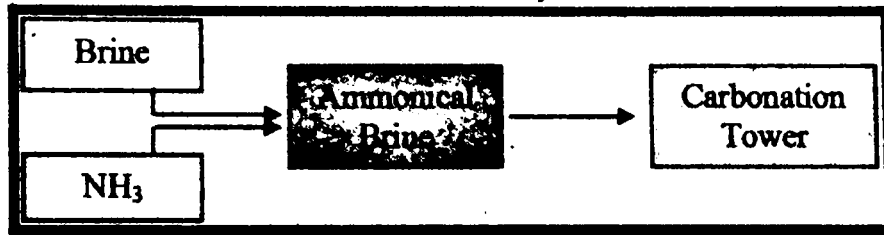


Almost all the ammonia is recovered in this process. It is reused in the process.

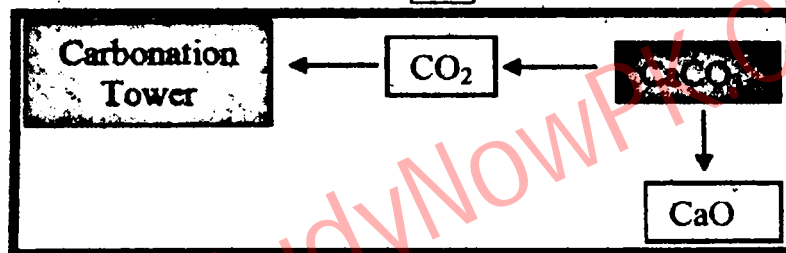
8. Draw flow sheet diagram of Solvay process.

Ans: Carry out the following:

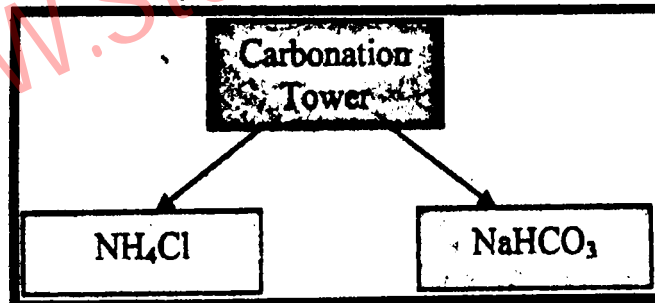
1. Represent each reactant, each product and each reaction chamber or container with one box.
2. Show formation of ammoniacal brine and join it with carbonation tower



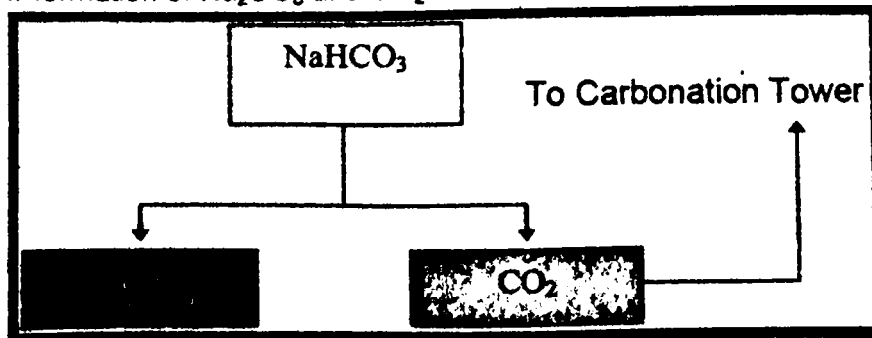
3. Show the formation of CO₂ with a box [CO₂] and connect it with carbonation tower.



4. Show formation of two products from the carbonation tower.



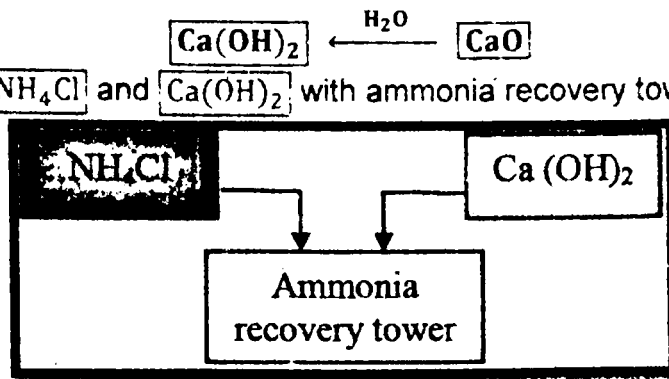
5. Show formation of Na₂CO₃ and CO₂ from NaHCO₃ and show recycling of CO₂.



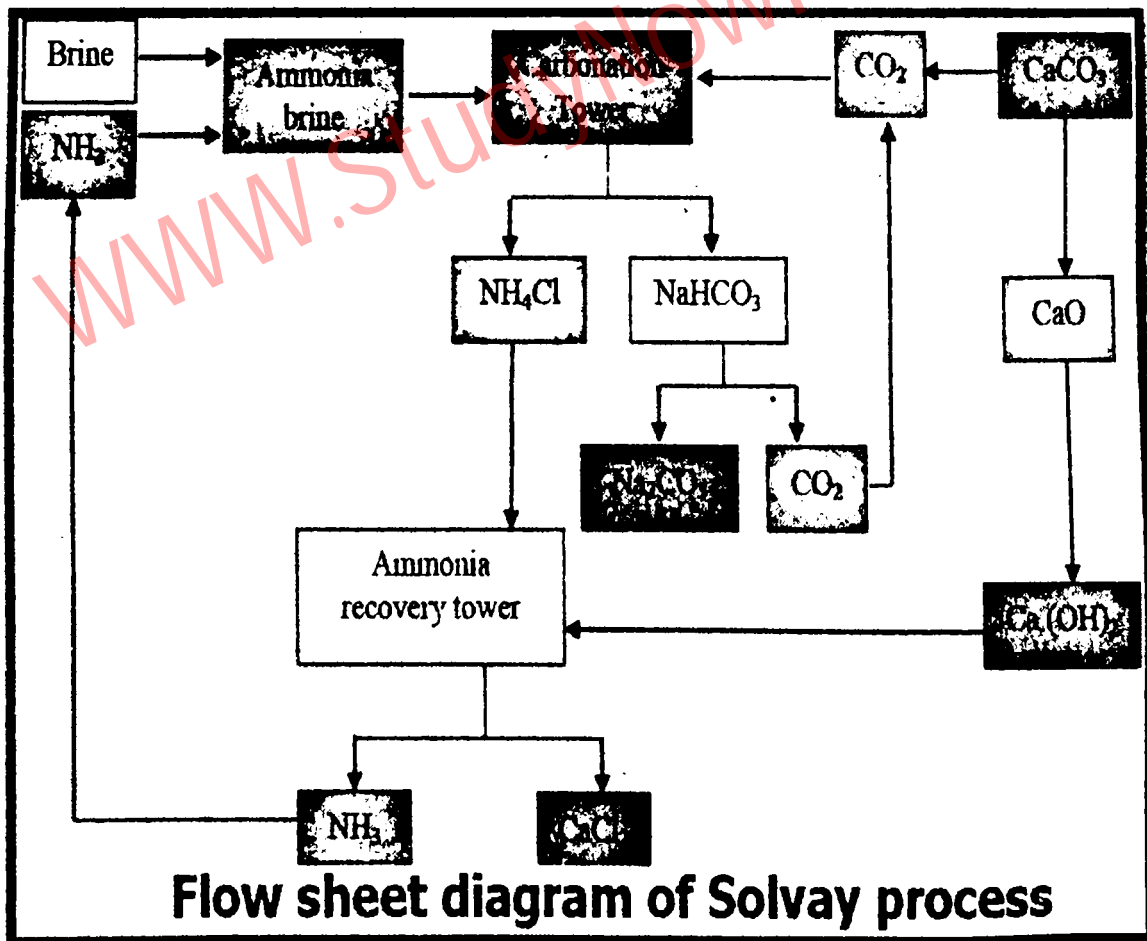
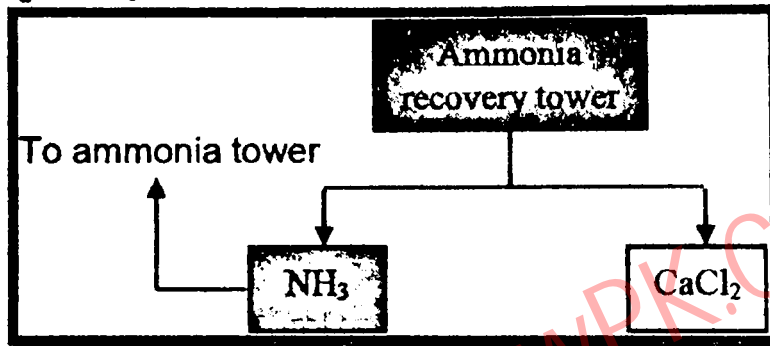
6. Show ammonia recovery:

a) First show formation of Ca(OH)₂ from CaO and H₂O.

b) Connect NH_4Cl and Ca(OH)_2 with ammonia recovery tower.

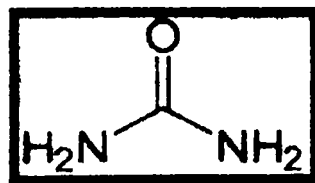


c) Show products of ammonia recovery tower, NH_3 and CaCl_2 . Also show recycling of NH_3



9. Describe composition of urea.**Ans: Urea:**

Urea or carbamide is an organic compound with the chemical formula $\text{CO}(\text{NH}_2)_2$. The molecule has two $-\text{NH}_2$ groups joined by a carbonyl ($\text{C}=\text{O}$) functional group.

**10. Make a list of raw materials for Solvay process.****Ans: Raw Materials:**

- Ammonia
- Brine (concentrated sodium chloride solution)
- Lime stone as a source of carbon dioxide and slaked lime, $\text{Ca}(\text{OH})_2$

11. Describe the composition of petroleum.**Ans: Composition of Petroleum:**

Petroleum is essentially a mixture of hydrocarbons particularly alkanes, *cycloalkanes* and aromatic hydrocarbons. Apart from hydrocarbons it may also contain compounds containing oxygen and nitrogen.

12. Relate the study of chemistry to careers in industry.

Ans: A person who studies chemistry and works with chemicals is called as *chemist*. Chemists have opportunities in all the field of chemistry. For instance, *organic chemists* have good opportunities to work in industries like petroleum, petrochemical and pharmaceutical. They can research on new products, more effective medicines, new pesticides for better crops, new ways to help people reduce environmental pollution etc.

As a *food chemist*; you can work in food processing industry. You can discover new methods to store, improve texture and flavor of foods. In hospitals, chemists analyze blood, urine and stool samples to detect any disease, disease causing bacteria, virus, or other microorganisms.

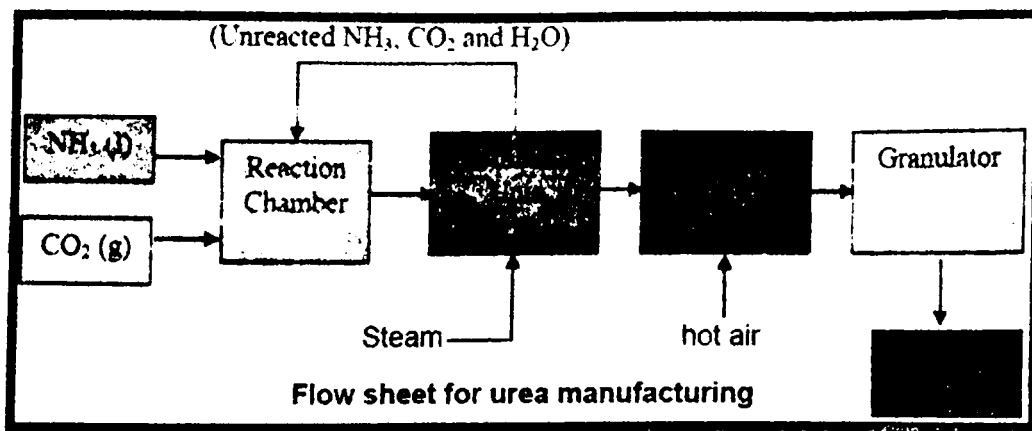
As *nuclear chemist* you can work in the development of new nuclear medicines besides giving chemotherapy and radiation therapy to cancer patients.

As *inorganic chemist* you can work in chemical industries such as manufacturing cement, glass, soap and detergent, fertilizer, acids, alkalis, soda ash, dyes, explosives etc.

13. Draw flow sheet diagram for manufacture of urea.**Ans: Carry out the following:**

- Represent each reactant, each product, reaction chamber, distillation chamber, evaporator, granulation and storage by boxes.
- Join these boxes and show the direction of the changes or processes.
- Show incoming of steam in distillation unit and hot air in evaporator.
- Show release of NH_3 , CO_2 and H_2O from distillation unit.

Solution:(Unreacted NH_3 , CO_2 and H_2O)



14. Petroleum is a mixture of several compounds, which are separated in a refinery.

- What is the name of the apparatus used for this purpose?
- What is the name of the process used in separating crude oil?
- Write name of the fraction that represents gases.
- Which fractions represent liquids with the lowest boiling points?

Ans: a) What is the name of the apparatus used for this purpose?

Fractionating tower

b) What is the name of the process used in separating crude oil?

Fractional distillation

c) Write name of the fraction that represents gases.

Liquefied petroleum gas (LPG)

d) Which fractions represent liquids with the lowest boiling points?

Petrol ($35^{\circ}\text{C} - 70^{\circ}\text{C}$)

15. Petroleum is a source of fuels. Name two fuels which are not obtained from petroleum.

Ans: There are several types, such as hydrogen fuel (for automotive uses), ethanol, and biodiesel, which are also categorized as a liquid fuel.

16. What has to be done to crude oil before it is useful?

Ans: Crude oil is a mixture of hydrocarbons. These are separated into useful products, such as fuels, using a process called fractional distillation in fractionating tower.

THINK-TANK

17. The table below lists some petroleum fractions with their approximate boiling points.

Fraction	Approximate Boiling Point/ $^{\circ}\text{C}$
P	Below 20
Q	35-70
R	170-250
S	350-500

a) Name the process by which the fractions are obtained from petroleum?

- b) Which fraction will contain the shortest chain molecules?
 c) Which fraction will contain the longest chain molecules?
 d) In what state will fraction P be at room temperature and pressure?

Ans: a) Name the process by which the fractions are obtained from petroleum?
 Refining.

b) Which fraction will contain the shortest chain molecules?
 Fraction P, liquefied petroleum gas (LPG).

c) Which fraction will contain the longest chain molecules?
 Fraction S, lubricating oil.

d) In what state will fraction P be at room temperature and pressure?
 Gas

18. Should fossil fuels be burned to provide energy, or should they be used to make useful products like drugs, plastics and chemicals?

Ans: Hemp oil or hempseed oil is obtained by pressing hemp seeds can be used to create biofuels to replace gasoline for diesel engines. Unlike fossil fuels, biofuels are renewable and produce less of the greenhouse gas carbon monoxide.

Therefore fossil fuels should be used to make useful products like drugs, plastics and chemicals.

19. Sketch flow sheet diagram of refining of petroleum.

Ans: Flow sheet diagram of refining of petroleum:

