2. Give short answers.

i. How are urea prills produce?

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.

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

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

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

iii. Write chemical reactions that take place during carbonation in Solvay process.

Ans: 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.

iv. Explain the process "Roasting" with two examples.

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

$$2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{heat} 2ZnO_{(s)} + 2SO_{2(g)}$$

Roasting reaction for cinnabar (HgS) is

$$HgS_{(s)} + O_{2(g)} \xrightarrow{heat} Hg_{(l)} + SO_{2(g)}$$

Roasting reaction of copper pyrite ore is

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

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

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

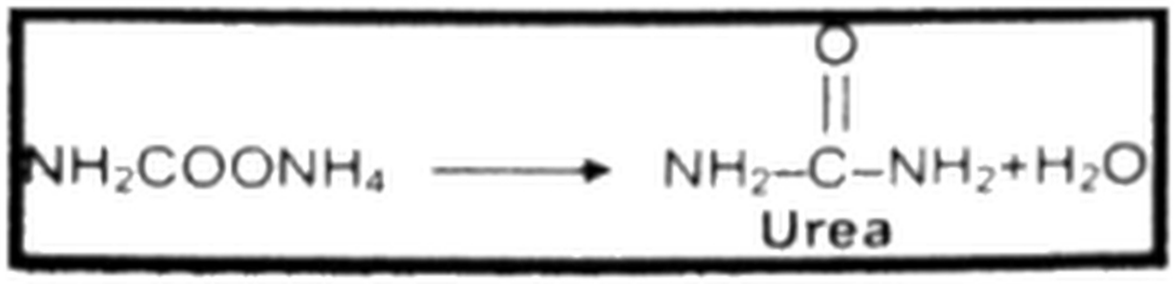
Manufacturing of urea consists of following steps.

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

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

$$NH_{3(l)} + CO_{2(l)} \rightarrow NH_2CONH_4 + H_2O$$

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

$$2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{heat} 2ZnO_{(s)} + 2SO_{2(g)}$$

Roasting reaction for cinnabar (HgS) is

$$HgS_{(s)} + O_{2(g)} \xrightarrow{heat} Hg_{(l)} + SO_{2(g)}$$

Roasting reaction of copper pyrite ore is

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

(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:

$$Fe_2O_{3(s)} + CO_{(g)} \rightarrow 2Fe_{(l)} + 3CO_{2(g)}$$

$$WO_{3(s)} + 3H_{2(g)} \rightarrow W_{(s)} + 3H_2O_{(l)}$$

$$ZnO_{(s)} + C_{(s)} \rightarrow Zn_{(s)} + CO_{(g)}$$

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

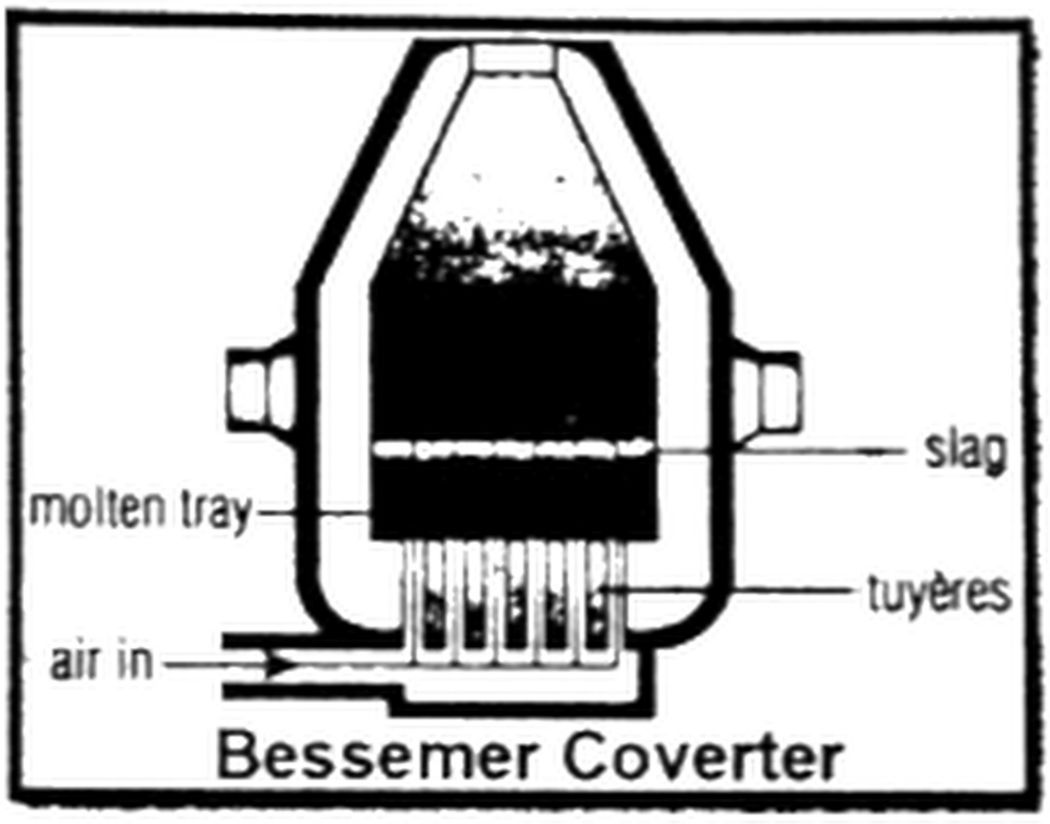
1. The roasted copper ore is heated with coke and sand at about 1100°C. The materials, melt and separate into two layers. The bottom layer that contains mixture of Cu_2S and FeS is called matte. While the upper layer is a silicate slag formed by the reaction of FeO and sand

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

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

2. 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.



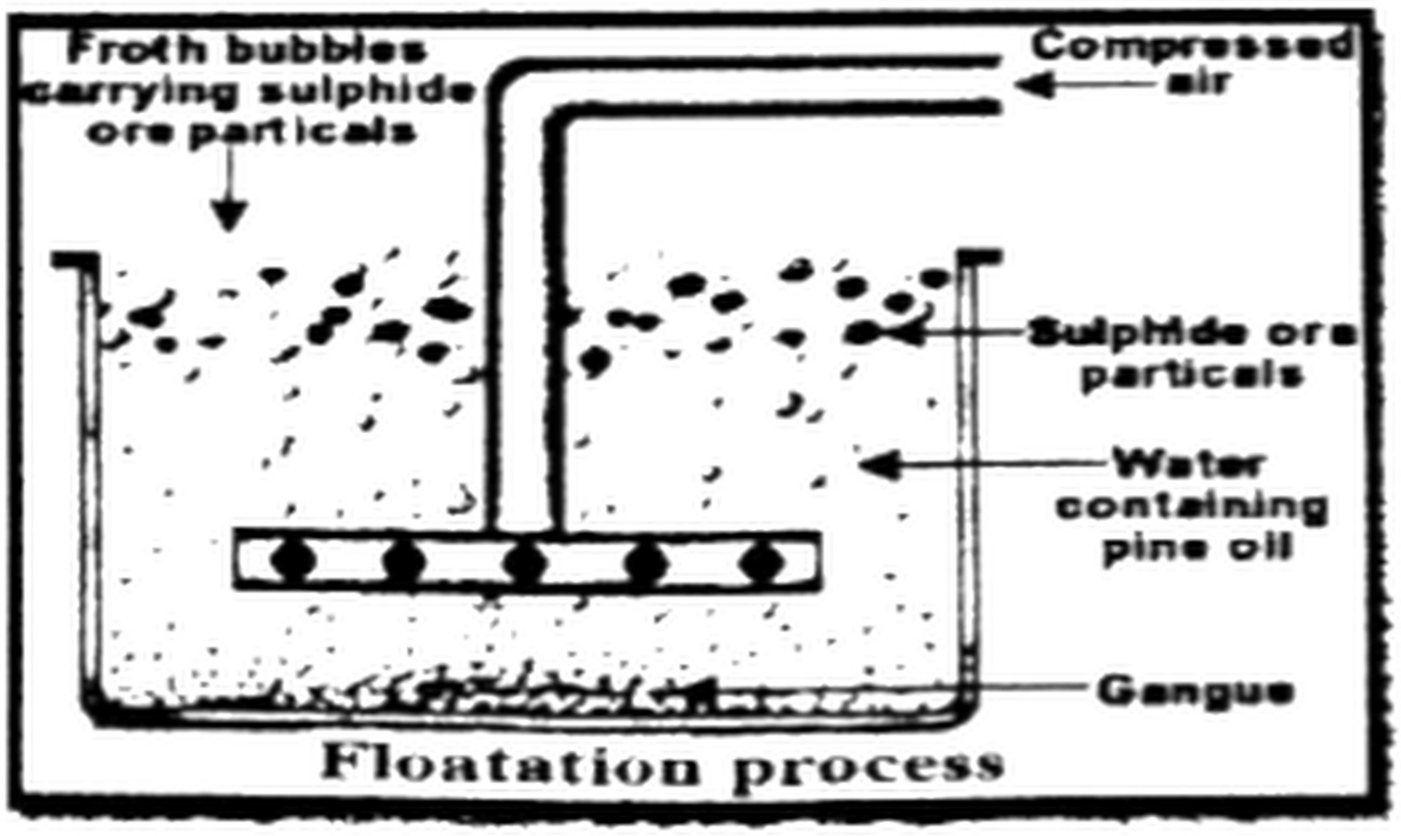
$$2Cu_2S_{(l)} + 3O_{2(g)} \rightarrow 2Cu_2O_{(l)} + 2SO_{2(g)}$$

$$Cu_2S_{(l)} + 2Cu_2O_{(l)} \rightarrow 6Cu_{(l)} + SO_{2(g)}$$

The product, called blister copper is about 97 to 99% pure Cu, with entrapped bubbles of SO_2 (g) Bessemerization is also used to convert pure iron into steel.

(c) Flotation process:

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



Floatation 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 ad bacterial effect changed the material into dark brownish viscous liquid called petroleum. It is 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.

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

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

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.

iv) Calcinations:

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 ar e 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.

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

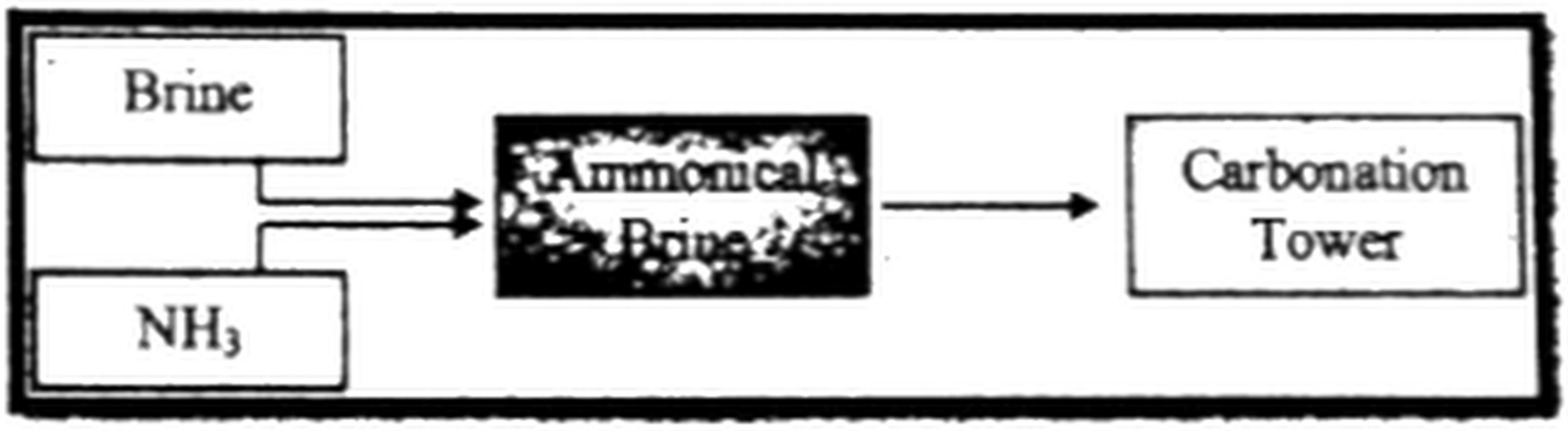
Almost all the ammonia is recovered in this process. It is reused in the process.

8. Draw flow sheet diagram of Solvay process.

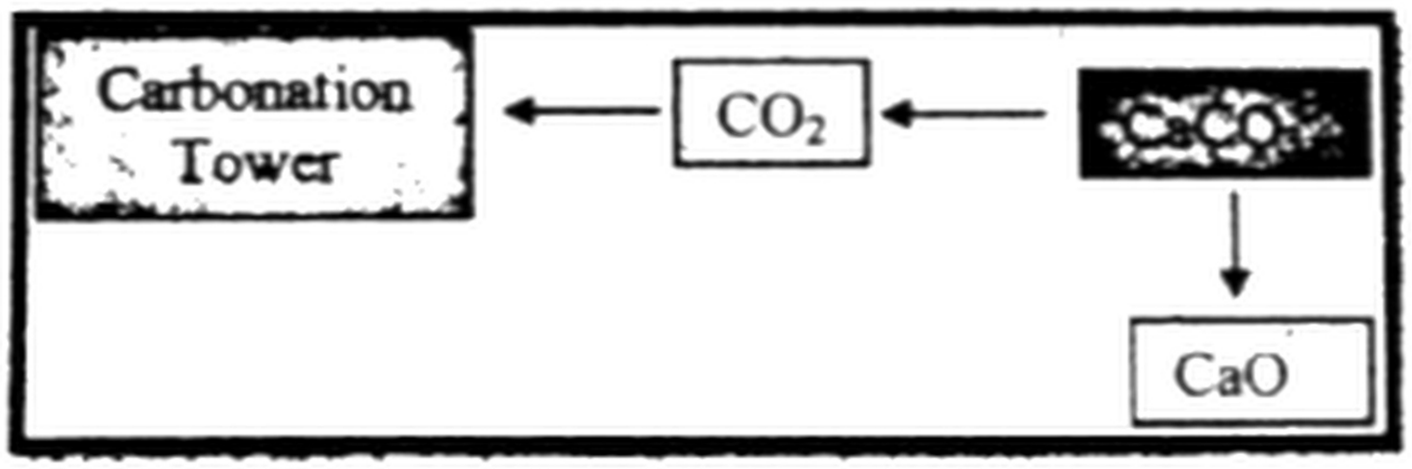
Ans: Carry out the following:

1. Represent each reactant, each product and each reaction chamber or container with one box.

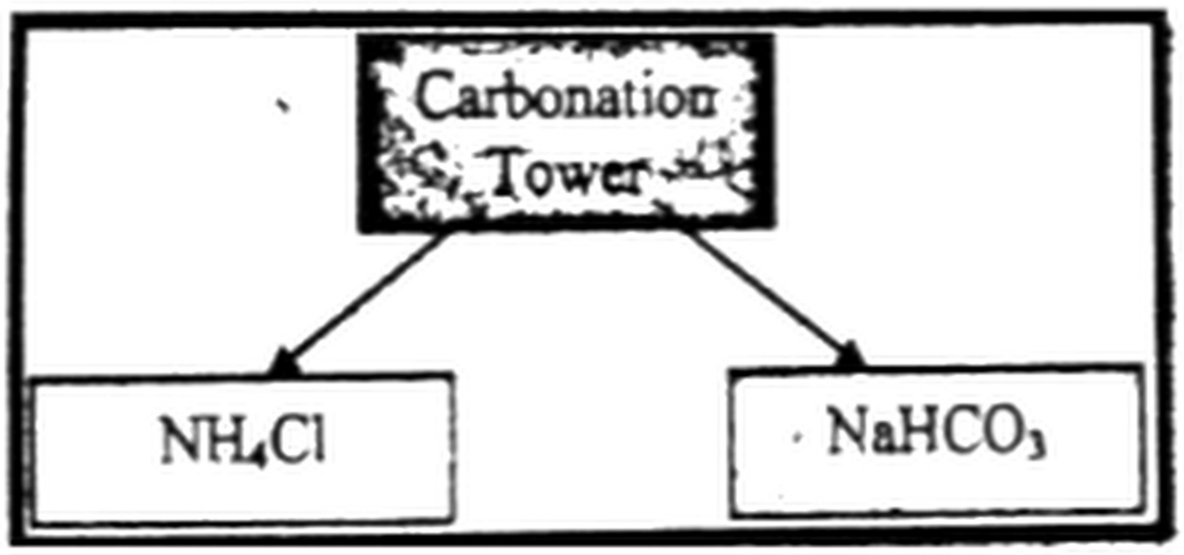
2. Show formation of ammonical brine and join it with carbonation tower



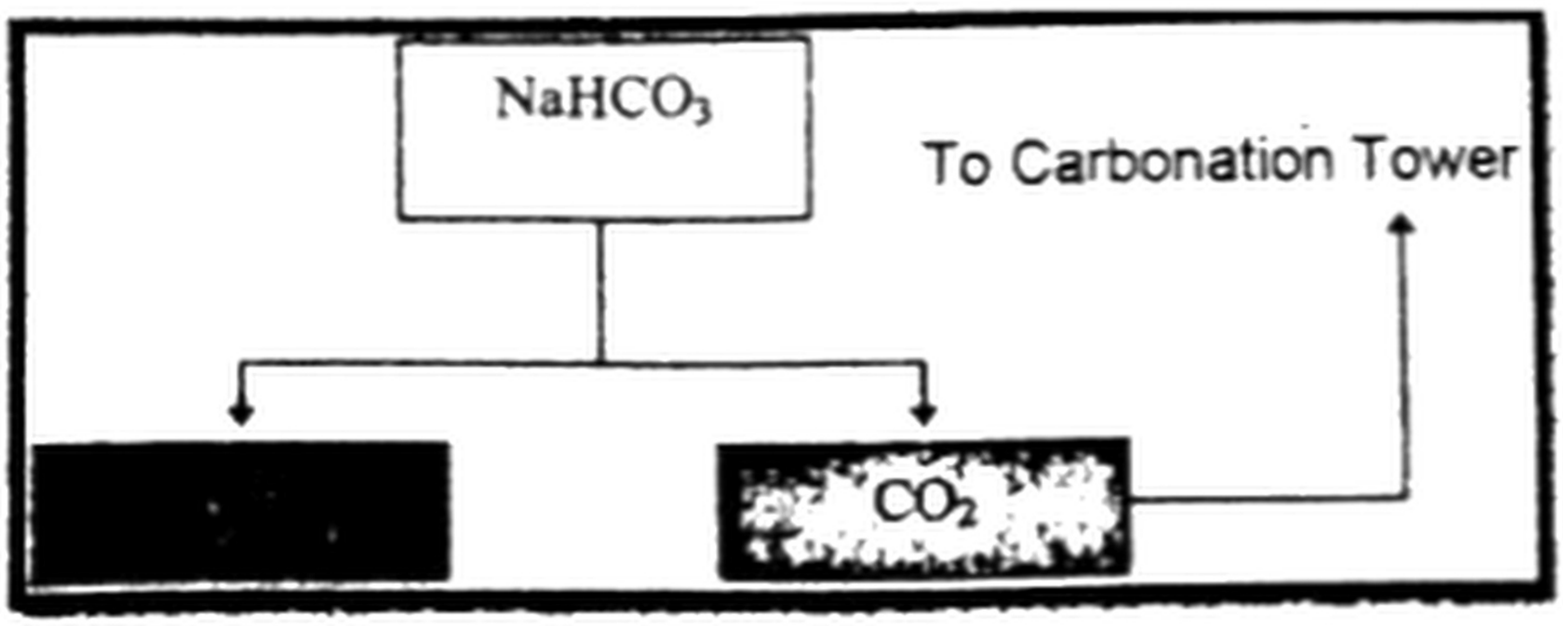
3. Show the formation of CO_2 with a box $\boxed{CO_2}$ and connect it with carbonation tower.



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



5. Show formation of NA_2CO_3 and CO_2 from $NaHCO_3$ and show recycling of CO_2

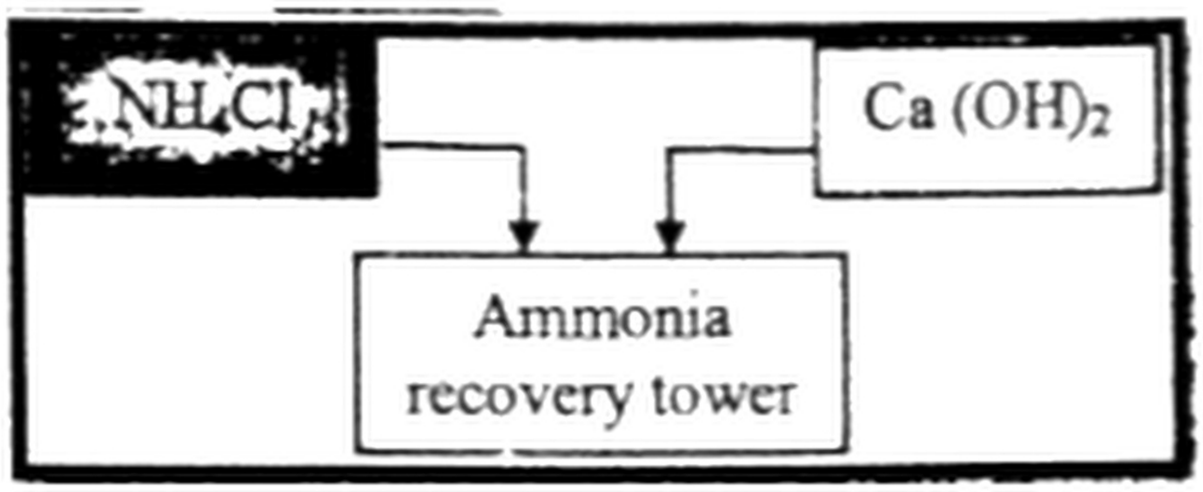


6. Show ammonia recovery:

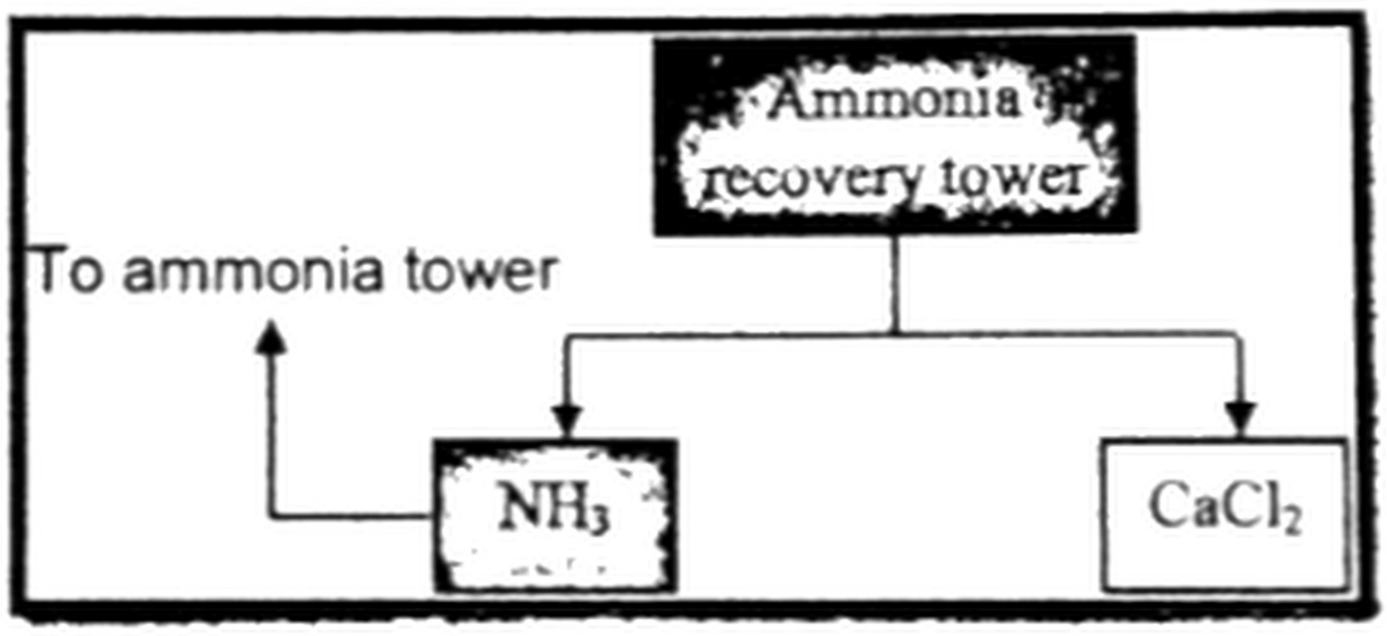
a) First show formation of $Ca(OH)_2$ from CaO and H_2O.

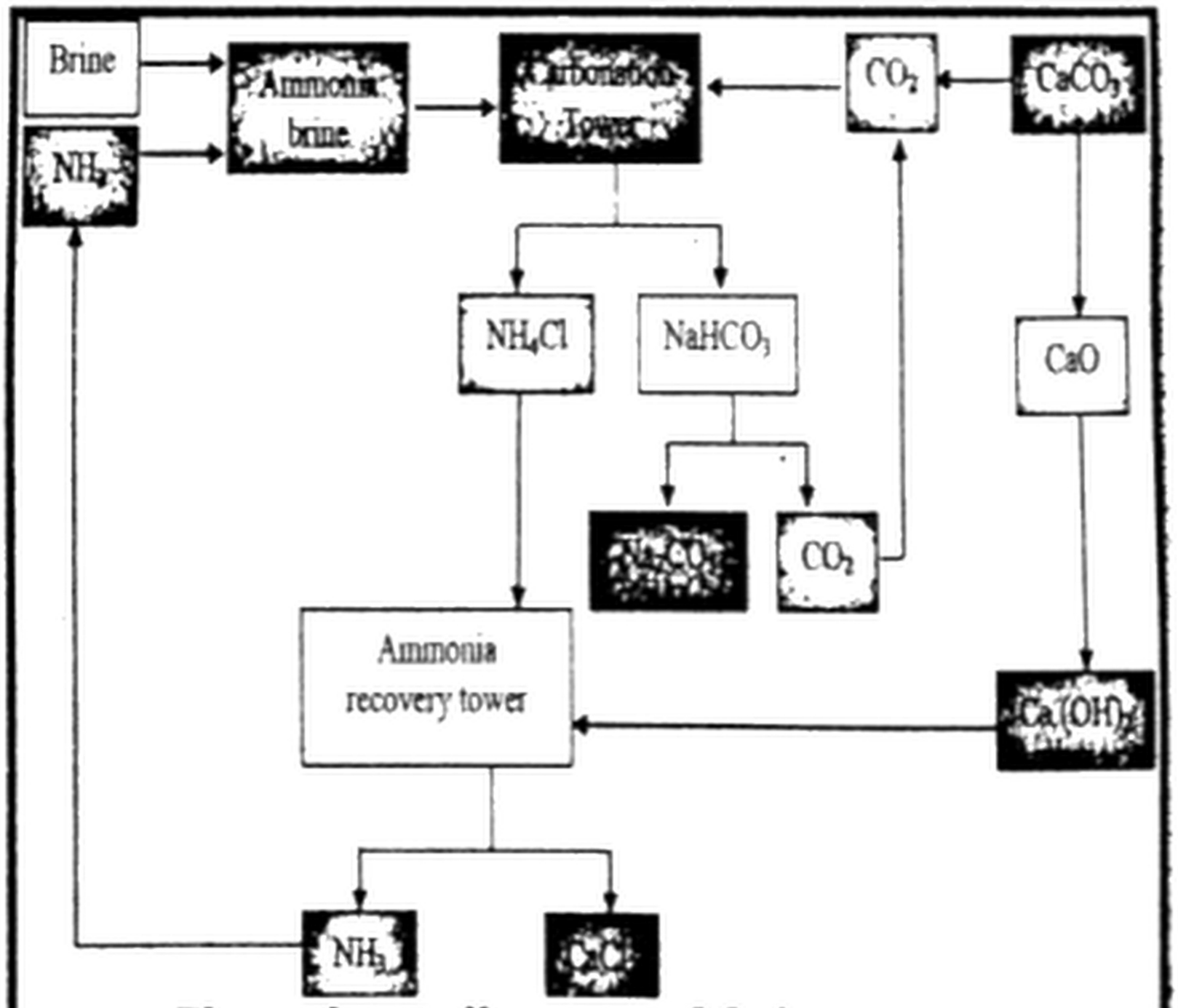
$$\boxed{Ca(OH)_2} \xleftarrow{H_2O} \boxed{CaO}$$

b) Connect $\boxed{NH_4Cl}$ and $\boxed{Ca(OH)_2}$ with ammonia recovery tower.



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



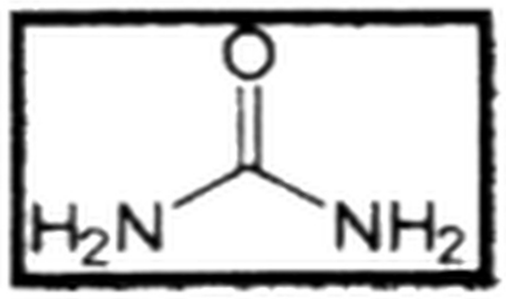


Flow sheet diagram of Solvay process

9. Describe composition of urea.

Ans: Urea:

Urea or carbamide is an organic compound with the chemical formula $CO(NH_2)_2$. The molecule has two $-NH_2$ groups joined by a carbonyl (C=O) functional group.



10. Make a list of raw materials for Solvay process.

Ans: Raw material:

a) Ammonia

b) Brine (concentrated sodium chloride solution)

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

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 t careers in industry.

Ans: A person who studies chemistry and works with chemical is called as *chemist.* Chemists have opportunities in all 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 stood 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.

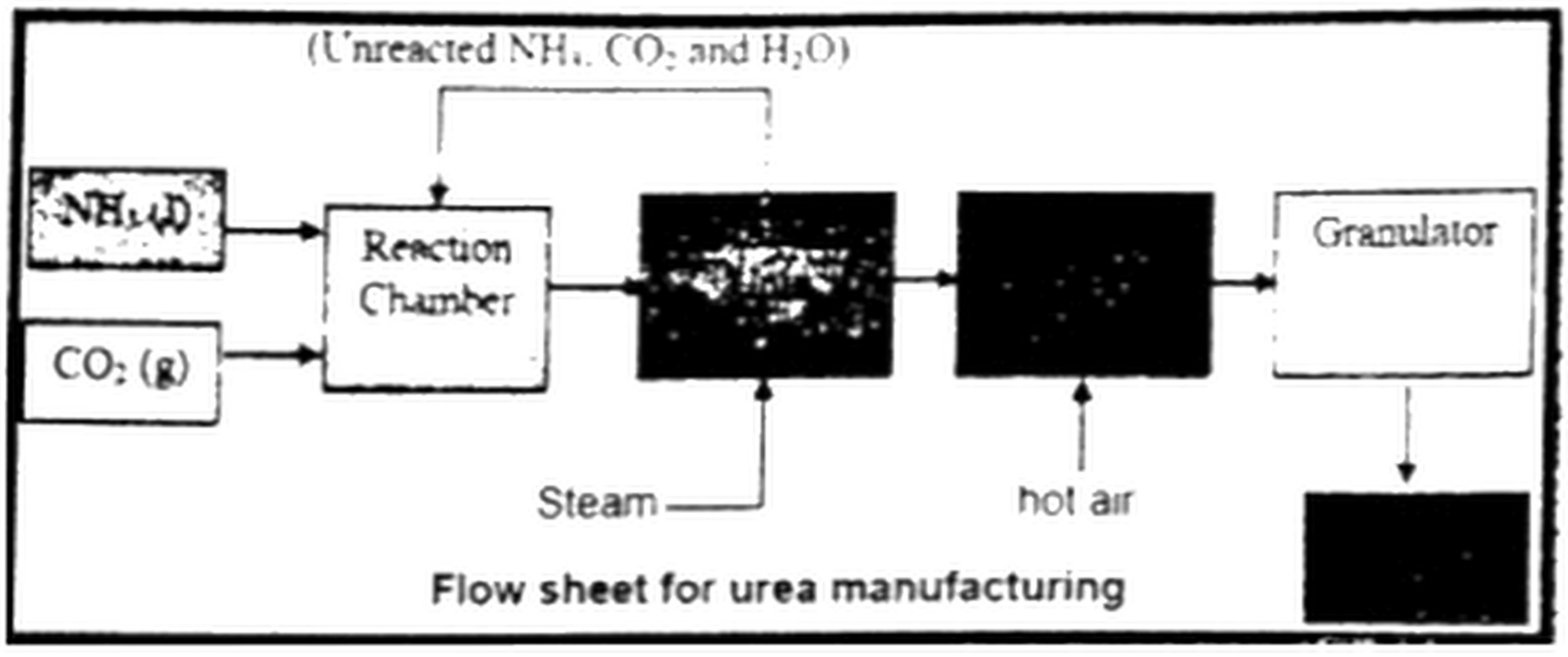
13. Draw flow sheet diagram for manufacture of urea.

Ans: Carry out the following:

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

Solution:

(unreacted NH_3, CO_2 and H_2O)



Flow sheet for urea manufacturing

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

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

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

c) Write name of the fraction that represents gases.

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

Petrol (35°C - 70°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/°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 shortest 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 shortest chain molecules?

Fraction S, lubricating oil

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

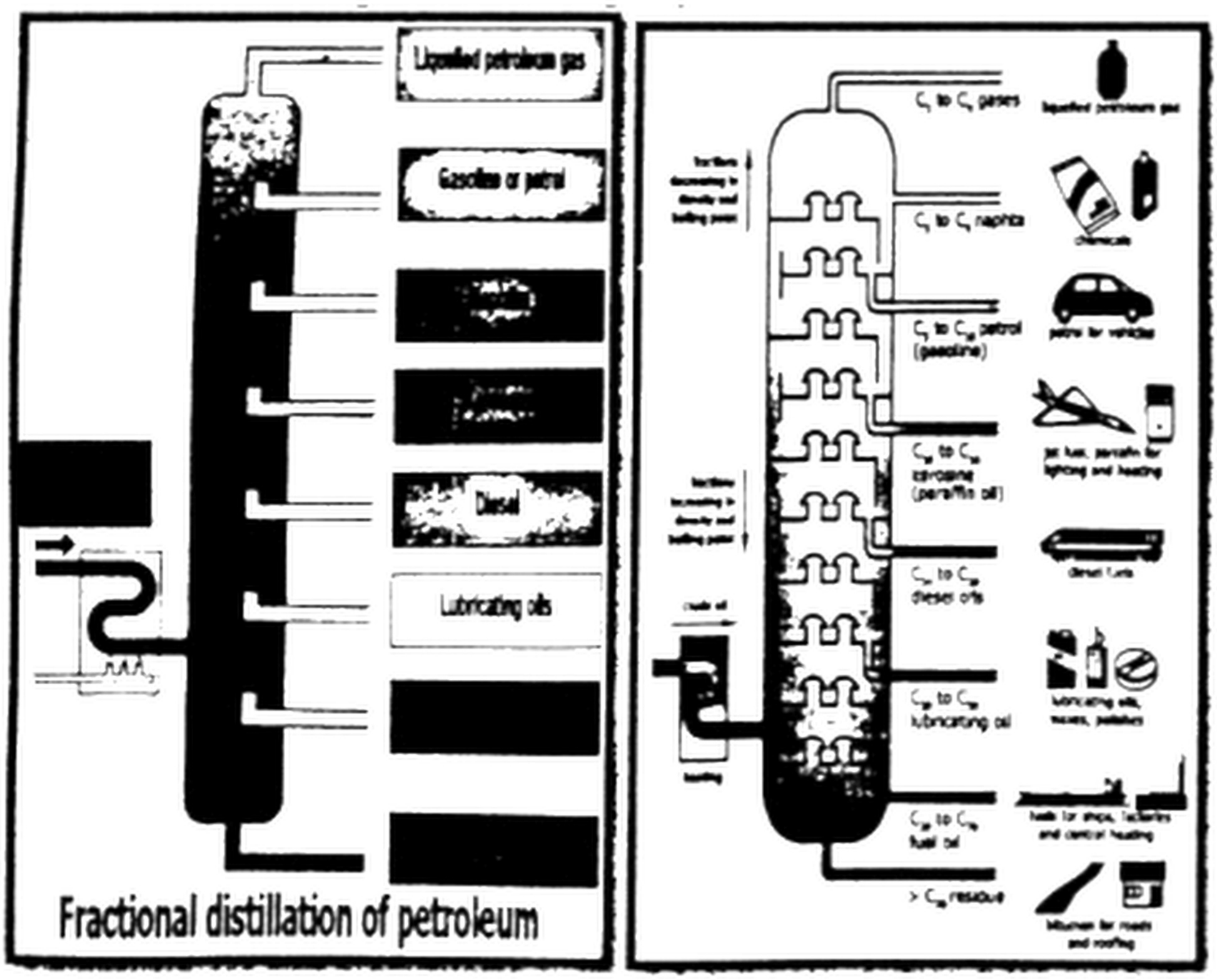
Gas

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:


Liquefied petroleum gas
Gasoline or petrol
Diesel
Lubricating oils
Fractional distillation of petroleum
C1 to C4 gases
C5 to C10 naphtha
C11 to C12 petrol (gasoline)
C13 to C15 kerosene (paraffin oil)
C16 to C20 diesel oils
C21 to C30 lubricating oil
C31 to C70 fuel oil
> C70 residue