Exercise

(A) State True or False Questions :

1. Ammonia can be easily obtained from H_2 and N_2.
2. Plants can assimilate nitrogen in the form of ammonia.
3. Nitrogen is very important ingredient required for the healthy growth of plants and animals.
4. Nitric acid is widely used acid in fertilizer industry.
5. 100% concentrated nitric acid can be obtained directly.
6. Among all the mineral acids, nitric acid is the strongest acid.
7. Sulphuric acid is a non-oxidizing strong acid.
8. Lead chamber process is out date now.
9. Platinum catalyst is superior to vanadium catalyst.
10. Sulphuric acid is a backbone of chemical industry.
11. In contact process, SO_2 is oxidized to SO_3 by contacting reacting gasses in the presence of catalyst.
12. The optimum temperature for the conversion of SO_2 to SO_3 is the room temperature.

Answers

1. (F)	2. (T)	3. (T)	4. (T)	5. (F)	6. (F)	7. (T)
8. (T)	9. (F)	10. (T)	11. (T)	12. (F)		

(B) Multiple Choice Questions :

(1) Catalyst used for the manufacture of ammonia is .....
- (a) chromium
- (b) iron
- (c) manganese
- (d) promoted iron

(2) Producer gas is a mixture of .....
- (a) $CO + N_2$
- (b) $CO + H_2$
- (c) $CO + CO_2$
- (d) $N_2 + H_2$

(3) Water gas is made from .....
- (a) coke and air
- (b) coke and steam
- (c) water
- (d) coke and CO

(4) % conversion of ammonia is found to ..... with increase of pressure.
- (a) increase
- (b) decrease
- (c) remain constant
- (d) first increases then decreases

(5) Too high space velocity is not desirable because .....
- (a) it decreases the rate of reaction
- (b) it increases the rate of reaction
- (c) it disturbs thermal balance of converter
- (d) none of these

(6) Sulphuric acid is made by .....
- (a) Haber process
- (b) Brickland process
- (c) Ostwald process
- (d) contact process

(7) Purification of reacting gases is not required when ..... is used as a starting material.
(a) pure air
(b) pure sulphur
(c) pure pyrite
(d) pure air and pure sulphur

(8) Which one of the following is an oxidizing acid ?
(a) HNO_3
(b) H_2SO_4
(c) HCl
(d) CH_3COOH

(9) Nitric acid obtained by Ostwald process is .....
(a) 100%
(b) 80%
(c) 60%
(d) 90%

(10) Ammonia is prepared by .....
(a) Ostwald's process
(b) contact process
(c) Haber-Bosch process
(d) none of these

(11) The catalyst used in the manufacture of nitric acid by Ostwald's process is .....
(a) Pt
(b) Pt-Rh
(c) Fe_2O_3
(d) V_2O_5

(12) Nitric acid is manufactured by .....
(a) Ostwald's process
(b) contact process
(c) Bosch-Haber process
(d) all of these

(13) Sulphuric acid of any desired composition is made by diluting .....
(a) oleum
(b) SO_3
(c) sulphuric acid
(d) all of these

(14) Ammonia at room temperature is in .....
(a) liquid form
(b) gas form
(c) solid form
(d) none of these

(15) Nitric acid is concentrated by .....
(a) Haber process
(b) contact process
(c) By using magnesium nitrate
(d) Ostwald process

(16) Sulphuric acid is used as .....
(a) protonating agent
(b) dehydrating agent
(c) strong acid
(d) all of these

(17) The efficiency of vanadium catalyst is .....
(a) less than 95%
(b) more than 95%
(c) 95%
(d) none of these

(18) Vanadium catalyst is .....
(a) cheaply available
(b) in the form of pellets
(c) more efficient
(d) all of these

(19) Optimum temperature range for the conversion of SO_2 to $SO_3$is .....
(a) 550-600
(b) 450-550
(c) 300-400
(d) 250-35

(20) Ammonia is used in making .....
(a) nitrogen containing compounds
(b) nitric acid
(c) nitrogenous fertilizers
(d) all of these

Answers

1. (d)	2. (a)	3. (b)	4. (a)	5. (c)
6. (d)	7. (d)	8. (a)	9. (d)	10.(c)
11. (b)	12.(a)	13. (a)	14.(b)	15. (c)
16. (d)	17. (b)	18. (d)	19. (b)	20. (d)

(C) Short and Long Answer Type Questions :

1. What is the importance of fixation of nitrogen ?
2. How nitrogen is naturally fixed ?
3. What is water gas and producer gas ? How they are produced ?
4. What was the initial discovery of Haber ?
5. What is the contribution of Bosch in the manufacture of ammonia ?
6. Describe with the help of flow diagram synthesis of ammonia by modified Haber-Bosch process.
7. Explain the principles involved in the manufacture of ammonia.
8. Why higher pressure like 100 atm is not generally used in the manufacture of ammonia ?
9. What do you mean by promoted iron ?
10. Why sulphuric acid is called backbone of chemical industry ?
11. Why contact process is the only process for the manufacture of H_2SO_4 ?
12. Describe the purification unit of sulphuric acid industry.
13. Why purification of reacting gases is necessary ?
14. Write a note on contact converter.
15. What is the use of heat exchanger system ?
16. Why SO_3 is not absorbed in water ?
17. What is oleum ? How it is converted into H_2SO_4 ?
18. Explain the physicochemical principles involved in the manufacture of H_2SO_4.
19. Define space velocity. What is the effect of very high space velocity ?
20. What do you mean by thermal balance of converter ?
21. What are the uses of NH_3, H_2SO_4 and HNO_3 ?
22. Compare between platinum catalyst and vanadium catalyst.
23. What is platinised asbestos ?
24. Explain Ostwald's process for manufacture of HNO_3.
25. Why nitric acid needs concentration ? How it is effected ?
26. What will happen if proportion of ammonia and air is not properly maintained ?
27. Explain the physicochemical principles involved in the oxidation of NH_3 to NO.
28. Write the various chemical reactions taking place during the manufacture of HNO_3.
29. Give important uses of ammonia.
30. Give important uses of sulphuric acid.
31. Give important uses of nitric acid.
32. What is oleum? How it is converted to H_2SO_4 ?
33. What are the uses of contact process ?

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* Chapter: 2. Manufacture of Basic Chemicals *

Ammonia, sulphuric acid and nitric acid are referred to as basic chemicals. These basic chemicals are used both in organic and inorganic chemical industries. NH_3 is a basic chemical required to produce nitrogen containing derivatives. It is also used in the manufacture of fertilizers, explosives and pharmaceuticals. Nitric acid is an oxidising acid. It is used in nitration reactions, in making nitrates, fertilizers, explosives, dyes etc. H_2SO_4 acid is called a back bone of chemical Industry.

Manufacture of

* (A) Ammonia: (NH_3): by Modified Bosch-Haber process:→

* **Manufacture of NH_3 by modified Haber-Bosch process:→**

- **Raw Material:→** H_2 and N_2 are the basic gases required for ammonia synthesis. H_2 can be obtained (i) by electrolysis of water (ii) from naphtha (iii) from coke oven gas (iv) from water gas and (v) by reacting natural gas with steam. N_2 can be obtained from (i) air and (ii) producer gas.
- **Principle:→** N_2 and H_2 is react in the volume ratio 1:3 under pressure and at an optimum temp. in presence of catalyst forms ammonia.
- **Reaction:→**

$$\underset{(1\ vol.)}{N_2} + \underset{(3\ vol.)}{3H_2} \rightleftharpoons \underset{(2\ vol.)}{2NH_3} + 92\ KJ.$$

* **Process:→**

In Haber process nitrogen is obtained from liquid air and hydrogen is obtained from steam.

In modified Bosch-Haber process nitrogen is obtained from producer gas ($CO + N_2$) and hydrogen is obtained from water gas ($CO + H_2$).

(a) Water gas is obtained from coke and steam by following chemical reaction: $2C + H_2O \xrightleftharpoons{1000-1400^{\circ}C} \underbrace{CO + H_2}_{\text{water gas.}} - 38.9\ Kcal.$

(b) Producer gas is obtained from coke and air by following chemical reaction: $2C + (O_2 + N_2) \rightleftharpoons \underbrace{2CO + N_2}_{\text{Producer gas}} + 28.9\,Kcal$
(coke, Air)

(c) Water and producer gas are mixed together such that after removal of CO, the proportion of N_2 and H_2 left is 1:3 by volume.

(d) Mixture of water gas ($H_2 + CO$) and producer gas ($CO + N_2$) is taken in oxidation tower, where carbon monoxide is oxidised to carbon dioxide by steam in presence of iron oxide catalyst promoted by Cr_2O_3 at 450°C. The reaction is

$$CO + H_2O \rightleftharpoons CO_2 + H_2 + 9.8\,K\cdot cal$$

(e) The gaseous mixture coming out of the oxidation tower consisting of hot $N_2 + H_2 + CO_2 + CO$, is now cooled by passing through a heat exchanger. The cooled gases are compressed to 25 atmosphere by passing through compressor. Further CO_2 is removed by dissolving in water under pressure.

(f) Little CO if there is removed by absorbing in a solution of ammonical cuprous formate kept in purifier.

(g) The mixture of pure N_2 and H_2 in the ratio 1:3 is compressed to 200-300 atmosphere and is filtered.

(h) The reacting gases ($N_2 + H_2$ 1:3) is now taken in a ammonia converter. Converter is a steel vessel containing finely divided iron catalyst with promoters such as molybdenum or mixture of oxides of Al, K and Ca. Catalyst temperature is maintained at 500-550°C.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 + Heat.$$

Reaction is exothermic, hence once it is started the desired temperature is maintained by adjusting the speed of entering gases.

(i) The exit gases contain 8% NH_3 and uncombined N_2 and H_2. Gases are cooled by passing through heat

exchanger. Most of their heat is given to incoming gases in the converter. Gaseous NH_3 is removed from N_2 and H_2 by condensation, first with water cooling and then by NH_3 refrigeration at $-15^\circ C$. The unreacted N_2 and H_2 are recycled. Liquified NH_3 is collected in a spherical storage tank.

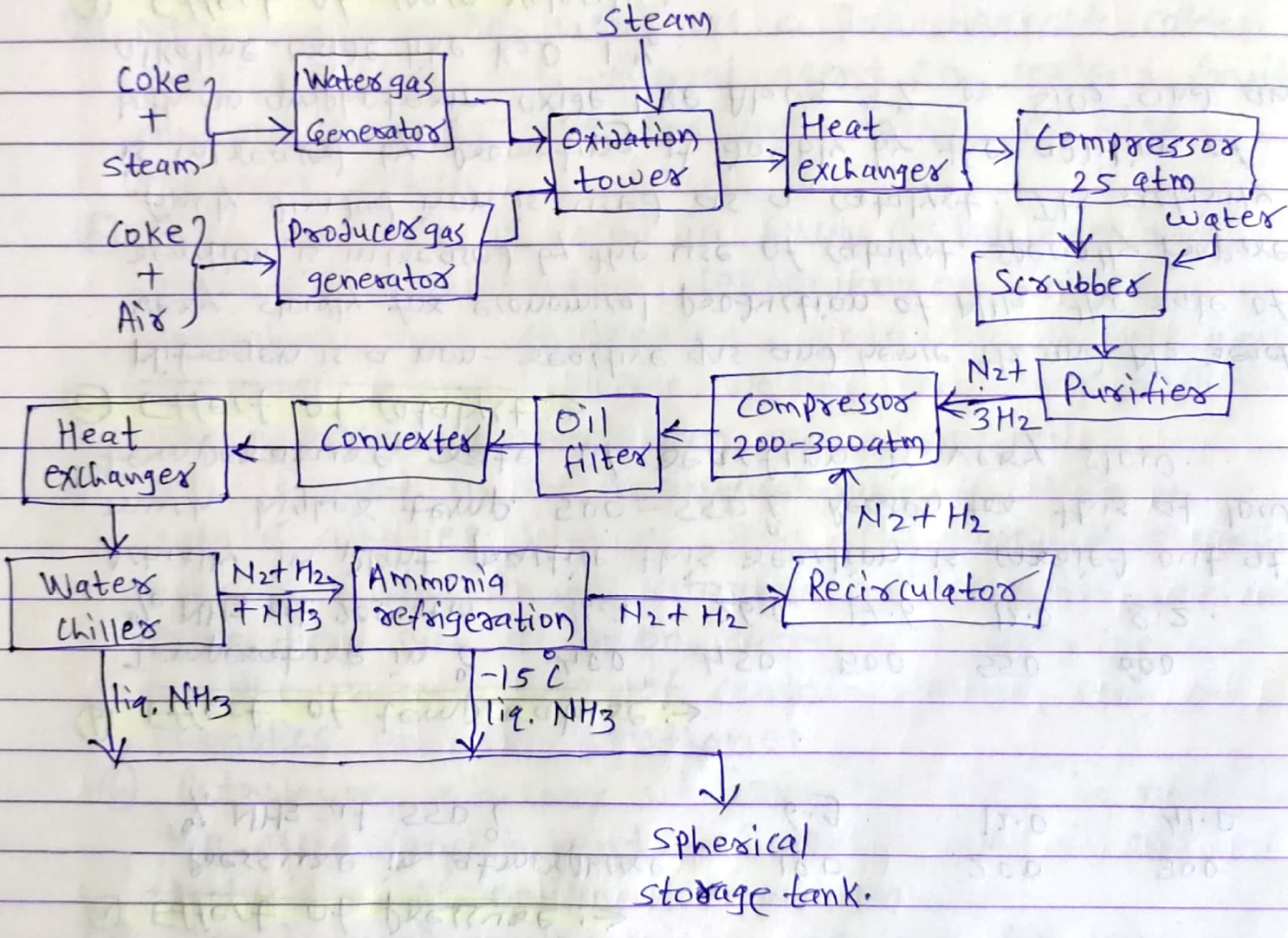


Fig: Flow sheet for Manufacture of NH_3 by Haber Bosch process:→

* Physico-chemical Principles:→ NH_3 synthesis is based on the reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + 22.0$ K.cal.
1 vol. 3 vol. 2 vol.

This reaction is reversible, gas phasic, forward reaction is exothermic and proceeds with decrease in volume. According to Le-Chatelier's principle, forward reaction is favoured by low temperature and high pressure.

(a) **Effect of pressure :⇒**

Pressure in atmosphere	100	200	300
% NH_3 at 550°C	6.9	12.0	41.0

(b) **Effect of temperature :⇒**

Temperature in °C	400	450	500	550	600
% NH_3 at 200 atm	36.3	26.0	17.6	12.0	8.2

Actually in plant practice this reaction is carried out at much higher temp. 500-550°C. Reason for this at low temperature rate of reaction is very slow.

(c) **Effect of catalyst :⇒**

Nitrogen is a non-reactive gas and hence H_2 and N_2 react very slowly for economical production of NH_3, the rate of reaction is increased by the use of catalyst. specially prepared finely divided iron is used as a catalyst. Its activity is increased by promoting it doubly by the addition of both an amphoteric oxide like Al_2O_3 3% or SiO_2 and an alkaline oxide like K_2O 1%.

(d) **Effect of space velocity :**

Space velocity is the number of cubic meters of reacting gases that pass over one cubic meter of the catalyst surface per hour. It must be properly adjusted too high space velocity results in

(i) Disturbance of the thermal balance of the converter.
(ii) Increase in cost of removal of NH_3 from unreacted gases.
(iii) Recirculation of large volumes of unreacted gases.

* Uses of Ammonia :→

① NH_3 is mainly used in agriculture industry to produce nitro-genous fertilizers. e.g. Urea and aqua NH_3, ammonium nitrate.

② NH_3 and Urea are used as a source of protein in live stock feeds for ruminating animals such as cattle, sheep and goats.

③ NH_3 can also be used as a pre-harvest cotton defoliant, an anti-fungal agent on certain fruits and as preservative for the storage of high moisture corn.

④ Dissociated NH_3 is used in such metal treating operations as nitriding, carbonitriding, bright annealing, furnace brazine, sintering, sodium hydride descaling, atomic hydrogen welding and other applications where protective atmosphere are required.

⑤ NH_3 is used in the manufacturing of HNO_3 acid, certain alkalies such as soda ash, dyes, Pharmaceuticals such as sulpha drugs, vitamins and cosmetics, synthetic textile fibre such as nylon, rayon and acrylics and for the manufacture of certain plastics such as phenolics and polyurethanes.

⑥ Petroleum industry utilizes the NH_3 in neutralizing the acid constitutents of crude oil and for protection of equipment from corrosion.

⑦ NH_3 is used in the mining industry for extraction of metals such as copper, nickel and molybdenum from their ores.

⑧ Liquid NH_3 is the best known and most widely studied non aqueous ionising solvent.

(9) 5 to 10 % by weight NH_3 solutions are used as household cleaners particularly for glass.

(10) Aqueous solution of NH_3 also used as a reagent in various test in laboratory.

Manufacture of

(B) Nitric acid HNO_3 by Ostwald Process:

Ostwald Process is of the most common method used for the manufacture of nitric acid. It was developed in the year 1902 by a German chemist Wilhelm Ostwald. In this process ammonia is oxidised to HNO_3. Vanadium Pentaoxide (V_2O_5) is used as a catalyst in this method.

Two steps are involved in Ostwalds process:

(I) Catalytic oxidation reaction and (II) Absorption of NO_2 i.e. ~~formation HNO_3~~

(I) Catalytic Oxidation Reaction: Primary oxidation i.e. ~~formation nitric oxide~~ Conversion of Ammonia into nitric acid is the crucial step. The process begins in a catalyst chamber where one ammonia part and eight oxygen parts are introduced by volume. The chamber temp. is around 600°C and platinum gauze or copper and nickel catalyst is used. The oxidation of ammonia takes place and it is converted into nitric oxide (NO). The process is reversible and exothermic.

$$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O \quad \Delta H = -24.8 \text{ K.cal/mol}$$

Secondary oxidation i.e. formation of Nitrogen Dioxide:

The nitric oxide gas produced by oxidation of NH_3 is in a very hot state. Then it is passed through a heat exchanger in which the temperature of nitric oxide is lowered to 150°C. After cooling nitric oxide is transferred to another oxidising tower where nitrogen dioxide (NO_2) is oxidised at about 50°C.

$$2NO + O_2 \rightleftharpoons 2NO_2$$

(II) Absorption of NO_2 i.e. formation of HNO_3:

The absorption tower containing water, nitrogen from the secondary oxidation chamber is introduced. NO_2 gas is passed through a tower where it absorbs the water. HNO_3 acid is then obtained. $3NO_2 + H_2O \rightleftharpoons 2HNO_3 + NO$.

The obtained nitric acid is very dilute and is dehydrated by distillation with H_2SO_4 acid. The pressure is kept between 4-10 atmosphere and the temperature is set at 700 - 800 °C. This reaction is exothermic. The water and oxygen are constantly added to this cycle as reactants, increasing concentration creates optimal equilibrium conditions.

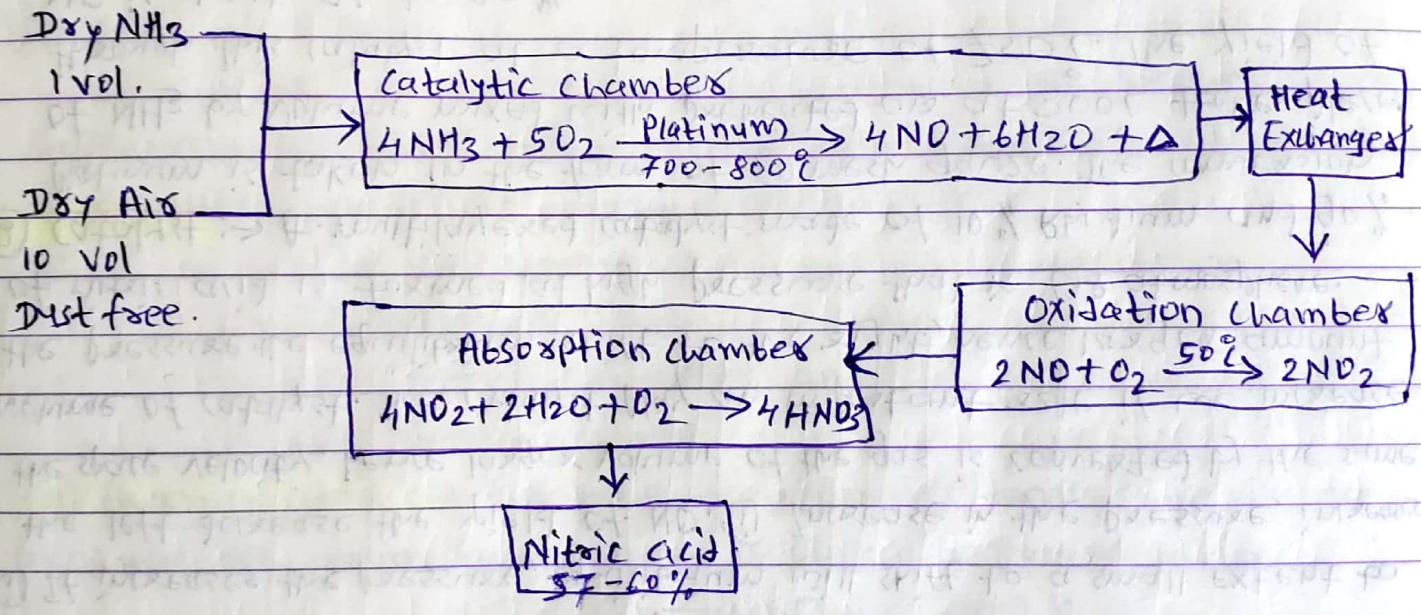


Fig: Manufacture of Nitric acid by Ostwald's Process:

* Physico-chemical principles: Ostwald's Process:

The most important step in the manufacture of nitric acid by Ostwald's process is the catalytic oxidation of NH_3 to NO. $4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$

$\Delta H = 905.2$ KJ/mole.

This reaction is reversible and forward reaction is exothermic.

(1) Temperature :→ Oxidation of NH_3 is a reversible and exothermic process. According to Le chateliers principle, a decrease in temp. favours reaction in forwarding direction. At low temp. the rate of reaction is slow. So an optimum temp. of about 750°C is kept when pressure is 6-8 atmosphere. At higher temp., there is a tendency of (i) NH_3 is get oxidized to N_2 and (ii) Decomposition of NO_2.

(2) Pressure :→ The forward reactions proceed with little increase in volume and backward reaction proceeds with little decrease in volume. (i) If increases the pressure, equilibrium will shift to a small extent to the left decrease the yield of NO. (ii) Increase in the pressure, increases the space velocity, hence larger volume of the gas is converted by the same volume of catalyst. The catalyst play an important role if we increase the pressure the equilibrium shift to the right, hence larger amount of nitric acid is formed at high pressure that is 6-8 atmosphere.

(3) Catalyst :→ A multilayered catalyst made of 10% Rhodium and 90% Platinum is taken in the form of 80 mesh gauze. The conversion of NH_3 by volume mixed with preheated air at 300°C takes places through this catalyst at a temperature of 750°C. The yield of NO is about 94 to 95%.

* Uses of Nitric acid :→

(1) It is used for the manufacture of fertilizers such as calcium nitrate, silver nitrate, ammonium nitrate etc.
(2) It is used in industries such as, Dyes, Perfumes, Drugs from coal tar product.
(3) It is also used in the manufacture of explosives like TNT, nitroglycerine etc.
(4) It is used as propellant in rocket as an oxidizer.
(5) It is used in the purification of gold and silver.
(6) It is used for purification of silver nitrate.

(7) It is used as reagent and to prepare aqua regia to dissolve the noble elements in laboratory.

(C) Manufacture of Sulfuric acid (H_2SO_4) by Contact Process :→

Contact process is based on catalytic oxidation of SO_2 to SO_3 and absorption of SO_3 in water to produce H_2SO_4.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

Both reactants and products are gases, success of reaction depends on catalytic conversion of reactants into products. When reactants are kept in contact with catalyst, they get converted into product, hence this process is popularly known as contact process.

The basic raw material required for this process is mainly sulphur or metallic sulphide, dry air and steam. The plant used in contact process can be divided into four units.

(a) Burner unit.
(b) Purifying unit.
(c) Contact converter and
(d) Absorption unit.

(a) Burner unit :→ The main function of burner unit is to produce SO_2 from by burning sulphur or pyrite in air.

$$S + O_2 \longrightarrow SO_2 + 71.0 \text{ K.cal}$$

or $4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2 + 82.2$ K.cal

For burning pure sulphur injection and cyclone furnace are used while burning of sulphides ore is done in pyrite burners. Other function of burner unit is to adjust the % of SO_2 and oxygen in the gases coming from burners. The % of SO_2 and O_2 are carefully controlled according to the catalyst used for the conversion of SO_2 to SO_3. For Platinum catalyst 10% SO_2 is needed while Vanadium catalyst 7-8% SO_2 is needed.

(b) Purifying unit :→ The purification of gases produced in burner unit is not essential when pure sulphur and pure air are used for the production of SO_2. When SO_2 is produced by burning sulphide ore, the burner gases may contain number of impurities such as sulphur or pyrite dust, As_2O_3, H_2SO_4 acid fog, chlorine, fluorine etc.

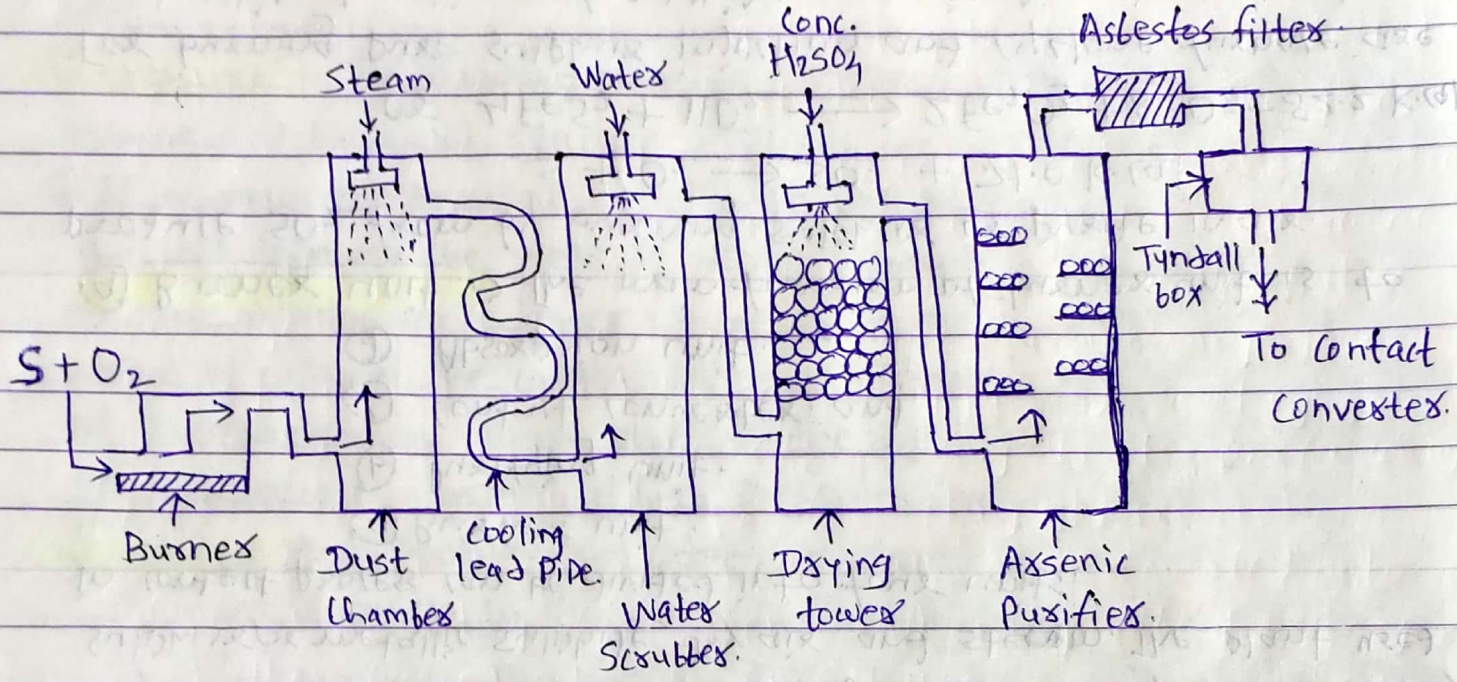


Fig :→ Burner and Purifying units of contact process :→

Burner gases are first passed through a dust chamber in which steam jets are introduced from the top. As up-going gases meet the down coming jet of steam, water droplet is formed around each dust particle, which becomes heavy and settle down easily. The very fine dust particles are made to settle with the help of controlled electrical precipitator.

Gases are then passed through cooling lead pipe to reduce their temperature down to about 100 °C. Then taken into water scrubber where these are washed by down coming spray of water. This treatment serves to remove H_2SO_4 acid fog as well as soluble gases, dust particles etc.

The gases are then dried by passing through the drying tower packed with pieces of quartz. Conc. H_2SO_4 acid flows down from the top and absorbs the moisture present in the gas. The gases are then passed through arsenic purifier which contains shelves on which basins containing ferric hydroxide are placed which absorb arsenic compounds.

The gases are then passed through a filter containing a layer of asbestos fibre which removes the last traces of dust and mist. Finally gases are passed through a Tyndall box to confirm that the gases are free from dust and As_2O_3 particles. In Tyndall box or testing box a strong beam of light is thrown against the flow of gases and if any particle is present it is detected due to Tyndall effect. Only the gases are free from impurities are allowed to go to the contact converter.

(C) Contact converter :⇒ In this unit SO_2 is oxidised to SO_3. Contact converter consists of an iron tower with iron pipes holding the catalyst.

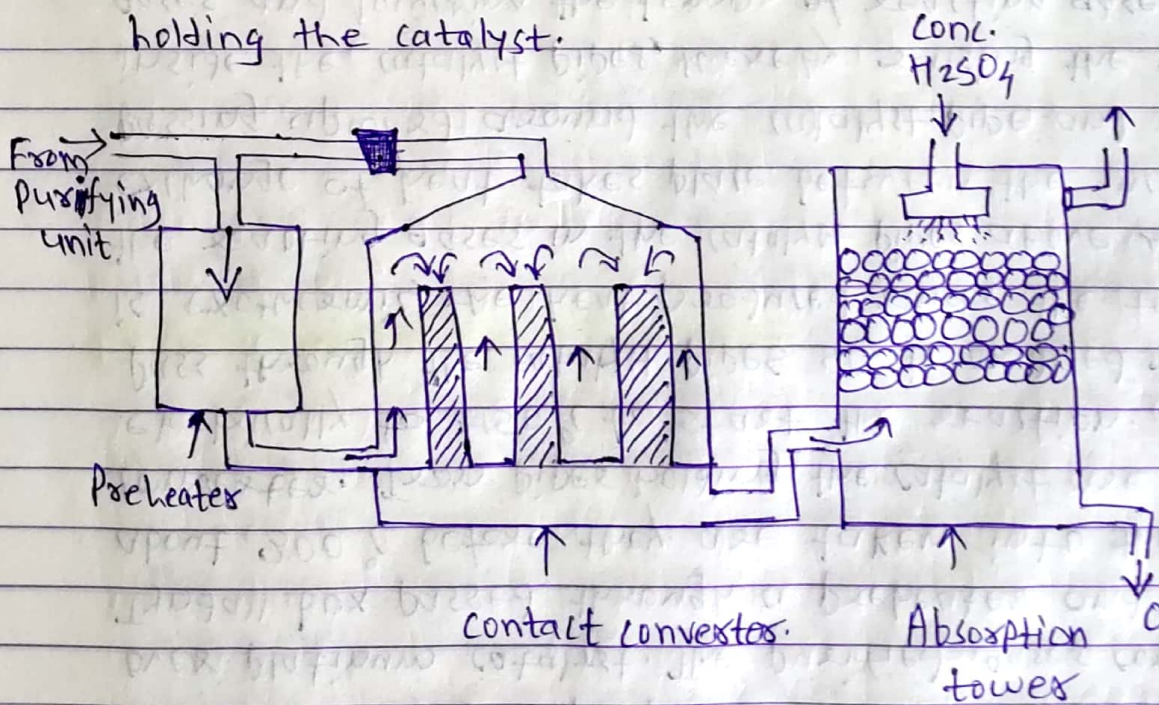


Fig. Contact converter and absorption unit.

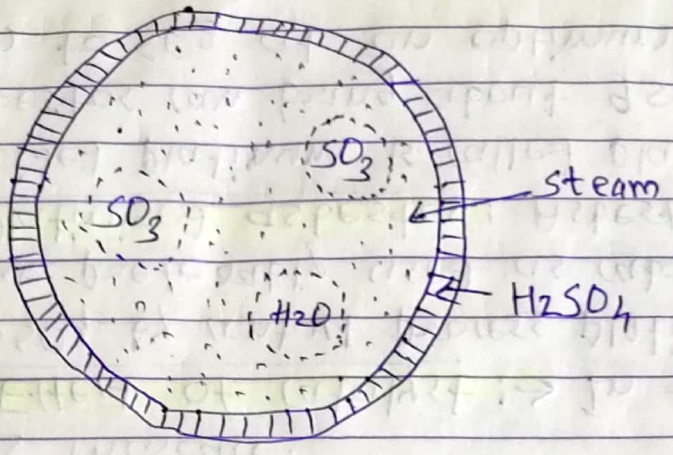
The catalyst may be either platinised asbestos or vanadium pentoxide. V_2O_5 is preferred because of its advantages over platinum catalyst. The purified gases coming out of Tyndall box passed through a preheater and heated to about 300°C before they are taken into the contact converter. Iron pipes holding the catalyst are also preheated electrically to 450°C to start the reaction. As the gases pass through the catalyst pipes SO_2 is oxidised to SO_3. Reaction is exothermic, the heat produced raises the temperature of the reacting gases in the catalyst pipes above 450°C. But exchange of heat takes place between the incoming gases passing upward around the catalyst pipe and reacting gases inside the catalyst pipes, thereby raising the temp. of incoming gases and lowering the temp. of reacting gases.

In contact converter nearly all SO_2 is converted into SO_3. The resulting SO_3 is then cooled using a heat exchanger and then passed into absorption tower.

(d) Absorption unit :⇒ SO_3 coming out from the contact converter cannot be directly absorbed in water as it results in the formation of dense H_2SO_4 acid fog or mist because of following exothermic reaction.

$$SO_3 + H_2O \longrightarrow H_2SO_4 + 21.3\ K\cdot cal.$$

The fog or mist consists of very small droplets of H_2SO_4 acid molecules enclosing the readily formed steam as well as unreacted water and SO_3. The droplet once formed cannot be condensed on cooling or broken down on boiling or any other means or dissolved in water. Inorder to avoid mist formation and hence loss of SO_3 it is absorbed in 100% H_2SO_4, SO_3 is absorbed in 100% H_2SO_4 to produce oleum.



$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
oleum.

This oleum diluted by water to obtain H_2SO_4.

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$
oleum — Sulphuric acid.

Fig: Fog or Mist droplet.

Contact process produces about 98 - 100 % conventrated H_2SO_4 acid.

* Physico-chemical principles :→

The most difficult step in the manufature of H_2SO_4 by contact process is the conversion of SO_2 to SO_3.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 + 196\ KJ.$$

2 vol. 1 vol. 2 vol.

The reaction is reversible and the forward reaction is exothermic. At low temp. rate of the reaction is slow. Hence in practice an optimum temp. is kept. A catalyst is used to hasten the rate of the reaction.

(1) Effect of temperature :→ The oxidation of SO_2 to SO_3 is an exothermic process. Experimentally it is found that rise in temperature decreases the conversion of SO_2 to SO_3.

At 400 °C the conversion of SO_2 to SO_3 is nearly 100 % but the rate of attainment of this equilibrium is very slow. The rate of reaction at 500 °C it is fastest but as increase in temperature decreases the yield of SO_3.

(2) Effect of pressure :⇒ The conversion of SO_2 to SO_3 takes place with decrease in volume. According to Le-Chatelier's principle increase in pressure should give more yield of SO_3 but SO_3 is strongly absorbed on the surface of the catalyst and it is through this layer of absorbed SO_3 that the gases SO_2 and O_2 have to diffuse and come in contact with the surface of catalyst. Increase in pressure increases the thickness of the absorbed layer of SO_3 and hence for gases SO_2 and O_2 find it difficult to come in contact and to react with each other on the surface of catalyst. Due to this reason high pressure is not employed and process is carried out at a pressure of 1.5 to 1.7 atmosphere.

(3) Effect of Concentration :⇒ According to Le-Chatelier's principle an increase in concentration of SO_2 in preference to O_2 would have more effect on shift of equilibrium because concentration of SO_2 appears as a square term in equation $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$

From this equation it is seen that the yield of SO_3 will increased when the concentration of SO_2 or O_2 is increase.

(4) Effect of catalyst :⇒ In the manufacturing of H_2SO_4 by contact process platinised asbestos and V_2O_5 are preferably used as catalyst.

(a) Platinised asbestos : Asbestos coated with finely divided platinum is called platinised asbestos. Platinised asbestos can bring about 95 - 96 % conversion of SO_2 to SO_3 at an optimum temperature of 450°C.

* Disadvantages of platinised Asbestos :=>

① It is very costly.
② It is difficult to handle.
③ It gets poisoned by the presence of traces of As_2O_3, AsH_3, Cl_2, HCl, HF, compounds of Pb and Sb.

⑥ Vanadium catalyst :=> V_2O_5 is very efficient and gives high conversion efficiency which is maintained for longer period. It has low initial cost and can be easily handled. There is no danger of poisoning.

* Uses of H_2SO_4 acid :=>

① It is extensively used in laboratory and in industry.
② H_2O_2 is obtained by the hydrolysis of persulphuric acid.
③ Concentrated H_2SO_4 and HNO_3 are used in preparation of explosives such as trinitro toluene (TNT), trinitrophenol (Picric acid), nitroglycerine, trinitro-cellulose.
④ The intermediate compounds in the preparation of dyes such as nitro benzene, nitro toluene H_2SO_4 acid is used.
⑤ It is used as a catalyst and as a dehydrating agent in esterification reactions.
⑥ It is used in the manufacture of fertilizers like superphosphate of lime, triple superphosphate and ammonium sulphate.
⑦ H_2SO_4 acid is used as electrolyte in lead acid batteries.
⑧ It is major ingradient in acidic drain cleaners.
⑨ It is used in dehydrating agent in esterification reaction.

—x—