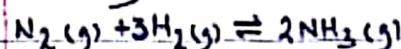


## 14. INDUSTRIAL MANUFACTURE OF AMMONIUM NITRATE

FERTILISER.

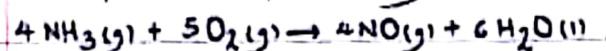
### A. PROCESS OF PRODUCTION:

Dry nitrogen and dry hydrogen are mixed in a ratio of 1:3 by volume respectively. The mixture is then heated in a reactor at a moderate temperature of about  $450^{\circ}\text{C}$  and high pressure between 200-1000 atmospheres in the presence of finely divided iron catalyst. The nitrogen reacts with the hydrogen to form ammonia.

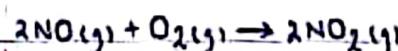


Ammonia is purified by methanation process.

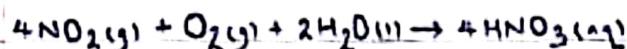
Dry ammonia is mixed with excess dry dust free air and passed over Platinum-Rhodium catalyst at red heat at a temperature of about  $900^{\circ}\text{C}$  and a pressure of 8 atmospheres to form nitrogen monoxide and water.



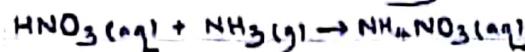
The nitrogen monoxide formed is rapidly cooled and further oxidised by oxygen from the excess air to form nitrogen dioxide.



The nitrogen dioxide, in the presence of more air, is then absorbed into hot water under pressure to form nitric acid.



Ammonium nitrate is obtained by reacting the nitric acid obtained with ammonia gas in a reactor.



The fertiliser is further concentrated, converted to solid form, and packed for storage.

### B. SOCIAL BENEFITS:

- Employment opportunities; income is earned; and hence improved standards of living.
- Development of infrastructure such as roads which facilitate trade. Locals will earn revenue; and hence improved standards of living.

### C. SIDE EFFECT :

- Air pollution due to leakage of ammonia.

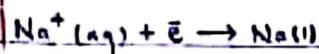
### 13. INDUSTRIAL MANUFACTURE OF SODIUM HYDROXIDE.

#### A. PROCESS OF PRODUCTION:

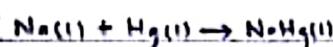
Sodium hydroxide is manufactured by electrolysis of brine in a mercury Cathode Cell using graphite anode and mercury Cathode:

The ions in brine migrate to oppositely charged electrodes.

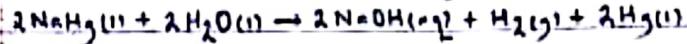
At the Cathode, Sodium ions are discharged by reduction to form sodium metal.



Sodium dissolves in mercury to form Sodium amalgam.



Sodium amalgam reacts with water in a water tank to form Sodium hydroxide solution, hydrogen and mercury.



Sodium hydroxide solution is evaporated to dryness leaving molten sodium hydroxide which solidifies into pellets upon cooling. The pellets are stored in air-tight containers.

#### B. SOCIAL BENEFITS:

Employment opportunities; income is earned; and hence improved standards of living.

Development of infrastructure such as roads which facilitate trade. Locals will earn revenue; and hence improved standards of living.

#### C. SIDE EFFECT :

Air pollution due to leakage of chlorine. Chlorine is:

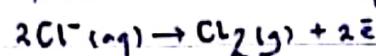
Toxic hence results into respiratory disorders when inhaled.

An acidic gas hence causes acid rain which leads to lowering of the pH of water or soil, crumbling of bridges or buildings, etc.

Mitigation can be done by regularly maintaining and monitoring the equipment.

N.B:

During the manufacture of Sodium hydroxide by electrolysis of brine, chlorine is formed at the anode.

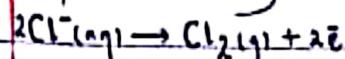


## 12. INDUSTRIAL MANUFACTURE OF CHLORINE.

### A. PROCESS OF PRODUCTION

Chlorine is manufactured by electrolysis of brine in a mercury cathode cell using graphite anode and mercury cathode:

- The ions in brine migrate to oppositely charged electrodes.
- At the anode, chloride ions are discharged by oxidation to form chlorine gas.



The chlorine is dried, liquefied and stored in tightly closed tanks.

### B. SOCIAL BENEFITS:

- Employment opportunities; income is earned; and hence improved standards of living.
- Development of infrastructure such as roads which facilitate trade. Locals will earn revenue; and hence improved standards of living.

### C. DANGER :

Air pollution due to leakage of chlorine. Chlorine:

- Is toxic hence results into respiratory disorders when inhaled.

- Is an acidic gas hence causes acid rain which leads to lowering of the pH of water or soil, crumbling of buildings or bridges, etc.

Mitigation can be done by:

- Regularly maintaining and monitoring the equipment

## 11. INDUSTRIAL MANUFACTURE OF CEMENT.

### A. PROCESS OF PRODUCTION:

Limestone is mixed with clay.

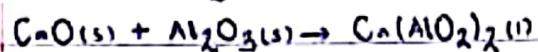
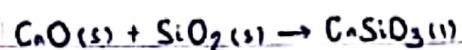
The mixture is crushed into a fine powder

The powder is mixed with water and allowed to flow down a rotating cylinder where it is strongly heated during the heating:

- Limestone decomposes into Calcium oxide and Carbon dioxide



- Calcium oxide reacts with the Silicon dioxide and the aluminium oxide present in the clay to form clinker which is Calcium silicate and Calcium aluminate



Clinker is cooled to solidify into lumps.

The lumps are crushed to obtain fine cement powder and gypsum is added during the grinding process to moderate the setting of cement

### B. SOCIAL BENEFITS:

- Employment opportunities; income is earned; and hence improved standards of living.

- Development of infrastructure such as roads which facilitate trade. Locals will earn revenue and hence improved standards of living.

### C. DANGER :

- Air pollution due to release of waste gases. Carbon dioxide is produced from the decomposition of limestone. Carbon dioxide is a greenhouse gas hence traps heat in the atmosphere when it accumulates leading to global warming. This can be mitigated by:

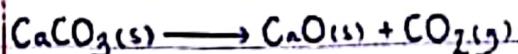
- Capturing Carbon dioxide emissions and storing them underground.

- Planting of trees to absorb Carbon dioxide.

## 10. INDUSTRIAL MANUFACTURE OF LIME;

### A. PROCESS OF PRODUCTION:

- Limestone is crushed and then strongly heated in a kiln.
- The limestone decomposes to form quicklime (Calcium oxide) and Carbon dioxide.



- The quicklime is cooled, crushed and then purified by sieving, use of a magnet, etc.

### B. SOCIAL BENEFIT:

- Employment opportunities; income is earned; and hence improved standards of living.

### C. DANGER :

- Air pollution due to release of waste gases. Carbon dioxide gas is produced from the decomposition of limestone. Carbon dioxide is a green house gas hence traps heat when it accumulates in the atmosphere leading to global warming. This can be mitigated by:

- Capturing Carbon dioxide emissions and storing them underground.
- Planting of trees to absorb Carbon dioxide.

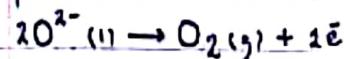
Anode in the oxygen produced at the anode:

Carbon dioxide is a greenhouse gas hence it traps heat in the atmosphere when it accumulates leading to global warming. This can be mitigated by:

- Implementing Carbon Capture and Storage technologies
- Planting trees to absorb Carbon dioxide

N.B:

During the extraction of aluminium, oxygen is produced at the anode:



The oxygen produced reacts with the Carbon anodes to form oxides of Carbon (Carbon dioxide and Carbon monoxide).

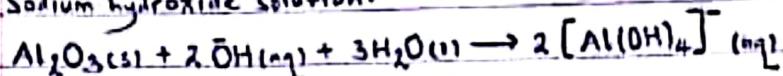
## 9. EXTRACTION OF ALUMINIUM.

### A. PROCESS OF PRODUCTION:

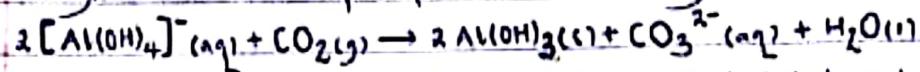
- Bauxite is roasted in air in a roaster to drive off water of crystallisation and to convert iron(II) compounds to iron(III) oxide.



- The roasted ore is crushed into fine powder in a crusher.
- The powder is digested with hot concentrated Sodium hydroxide solution under pressure in a tank. The amphoteric aluminium oxide and the acidic Silicon dioxide dissolve but the basic iron(III) oxide and titanium(IV) oxide do not dissolve in the Sodium hydroxide solution.



- The undissolved impurities are filtered off in a filter press.
- The filtrate is cooled and Carbon dioxide is bubbled through it in a tank to precipitate aluminium hydroxide.

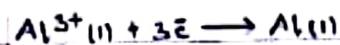


- The aluminium hydroxide is filtered off, washed, dried, and heated strongly to form pure aluminium oxide and water.



- The pure aluminium oxide is dissolved in molten cryolite and then electrolysed in an electrolytic cell (steel tank) using graphite electrodes. A low voltage and high current density are used. The temperature of the cell is maintained around  $950^\circ\text{C}$ .

At the Cathode, aluminium ions are discharged to form aluminium.



### B. SOCIAL BENEFITS:

- Employment opportunities; income is earned; and hence improved standards of living.

- Development of infrastructure such as roads which facilitate trade. Locals will earn revenue and hence improved standards of living.

### C. DANGER:

- Air pollution due to release of waste gases. Carbon dioxide gas is produced from the Combustion of the Carbon

gas is formed during the process of extraction.

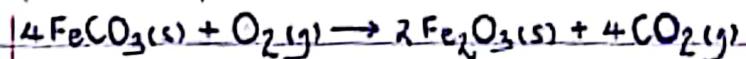
Carbon dioxide is a greenhouse gas hence it traps heat in the atmosphere when it accumulates leading to global warming. Mitigation can be done by:

- Implementing Carbon Capture and Storage technologies.
- Planting of trees to absorb Carbon dioxide.

## 8: EXTRACTION OF IRON:

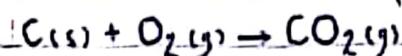
### A: PROCESS OF PRODUCTION:

Siderite (Sporadic iron ore) is roasted in air in a furnace to form iron(III) oxide and Carbon dioxide.

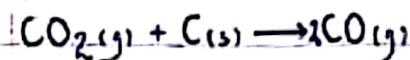


The iron(III) oxide is mixed with Coke and limestone. The mixture is fed into a blast furnace from the top and hot air is blown into the blast furnace from the bottom. In the blast furnace:

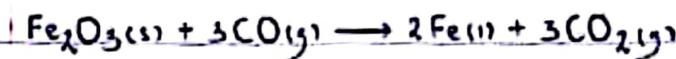
-Coke burns in air to form Carbon dioxide.



-The carbon dioxide formed is reduced by unburnt Coke to form Carbon monoxide.



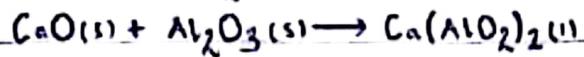
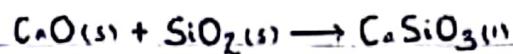
-Iron(III) oxide is reduced by Carbon monoxide to form iron and Carbon dioxide.



-Limestone is decomposed by heat to form Calcium oxide and Carbon dioxide.



-Calcium oxide which is a basic oxide reacts with the acidic Silicon dioxide and the amphoteric aluminium oxide present as impurities to form Slag (Calcium silicate and Calcium aluminate).



Slag floats on the top of molten iron at the bottom of the blast furnace and each is tapped off separately. The molten iron is called pig iron or cast iron.

### B: SOCIAL BENEFITS:

Employment opportunities; income is earned; and hence improved standards of living.

Development of infrastructure such as roads which facilitate trade. Locals will earn revenue and hence improved standards of living.

### C: SIDE EFFECT:

Air pollution due to release of waste gases. Carbon dioxide

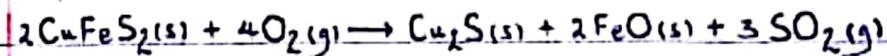
Mitigation can be done by building a Sulphuric acid manufacturing plant near the Copper extraction plant to utilise the Sulphur dioxide in the manufacture of Sulphuric acid.

## 7. EXTRACTION OF COPPER.

### A. PROCESS OF PRODUCTION:

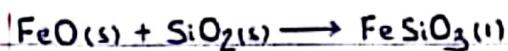
Copper pyrites is concentrated by froth flotation method in a concentration tank.

The concentrated and dried ore is roasted in air in a furnace to form Copper(II) Sulphide, iron(II) oxide and Sulphur dioxide.



The solid product of roasting is heated with silicon dioxide in a blast furnace in absence of air to remove iron(II) oxide.

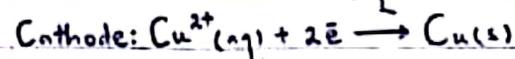
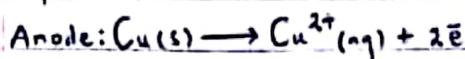
The iron(II) oxide reacts with the silicon dioxide to form iron(II) silicate.



Copper(I) sulphide is heated in a furnace in controlled amount of air to form impure copper and sulphur dioxide.



The impure copper is purified by electrolysis using impure copper as the anode and pure copper as the cathode in an electrolytic cell containing acidified Copper(II) sulphate solution as the electrolyte. During the electrolysis, impure copper dissolves to form Copper(II) ions and pure copper is deposited at the cathode.



### B. SOCIAL BENEFITS:

Employment opportunities; income is earned; and hence improved standards of living.

Development of infrastructure such as roads which facilitate trade. Locals will earn revenue and hence improved standards of living.

### C. DANGERS:

Air pollution due to release of waste gases. Sulphur dioxide gas is evolved as a byproduct. Sulphur dioxide:

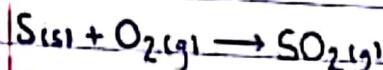
- Is an acidic gas hence causes acid rain which leads to lowering pH of the soil or water, crumbling of bridges or buildings, etc.

- Is poisonous leading to respiratory disorders when inhaled.

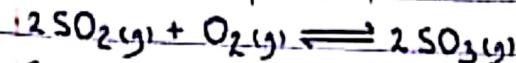
## 6: INDUSTRIAL MANUFACTURE OF SULPHURIC ACID BY THE CONTACT PROCESS.

### A. PROCESS OF PRODUCTION:

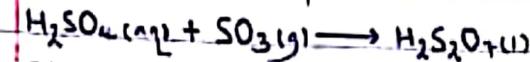
Sulphur is burnt in air in a burner (furnace) to form Sulphur dioxide.



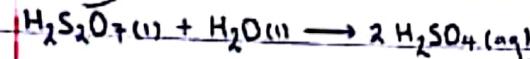
Sulphur dioxide is mixed with excess air, cleaned (purified) in a purifier, compressed, and passed over Vanadium(V) oxide Catalyst kept at 450-500°C in a catalytic chamber. The two gases react to form Sulphur trioxide.



Sulphur trioxide is absorbed in concentrated Sulphuric acid in the absorber to form Oleum



Oleum is diluted with the correct amount of water to give Ordinary concentrated Sulphuric acid in a dilutor.



### B. SOCIAL BENEFITS:

Employment opportunities; income is earned; and hence improved standards of living.

Development of infrastructure such as roads which facilitate trade. Locals will earn revenue and hence improved standards of living.

### C. DANGER

Air pollution due to release of waste gases. Waste acidic gases such as Sulphur dioxide, and Sulphur trioxide

Can cause acid rain which leads to lowering pH of the soil or water, crumbling of bridges or buildings, etc.

This can be mitigated by fitting scrubbers in exhaust pipes to absorb the acidic gases.

## 5. INDUSTRIAL MANUFACTURE OF BIOGAS

### A. PROCESS OF PRODUCTION:

Organic wastes are put in a tank and mixed with some little water.

The tank is covered to prevent aerial oxidation.

The tank and its contents are maintained at room temperature for about 2 weeks. Anerobic bacteria break down the organic matter to produce biogas.

Biogas can be purified by scrubbing, drying, etc. and then stored in gas cylinders under pressure.

### B. SOCIAL BENEFIT :

Employment opportunities; income is earned; and hence improved standards of living.

### C. DANGERS :

Explosion of biogas cylinders due to high pressure.

This can cause other materials to catch fire leading to injuries and loss of properties.

Mitigation can be done by:

- Keeping the cylinders in cool areas.

- Regularly monitoring and maintaining the cylinders.

Air pollution due to leakage of biogas. Biogas contains some traces of toxic ammonia and hydrogen sulphide which may cause stomach and respiratory disorders when inhaled.

Mitigation can be done by regular maintenance and monitoring of the cylinders or equipment.

### N.B:

Biogas contains mainly methane. It also contains other gases like Carbon dioxide, ammonia, hydrogen sulphide, etc.

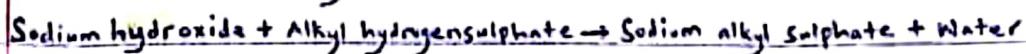
#### 4. INDUSTRIAL MANUFACTURE OF SOAPLESS DETERGENTS.

##### A. PROCESS OF PRODUCTION:

- A long chain alcohol is mixed with concentrated Sulphuric acid in a large tank while stirring. The alcohol reacts with the acid.



- The resultant mixture is treated with aqueous Sodium hydroxide solution to form a detergent



- The product is then evaporated to dryness, washed, and dried.

##### B. SOCIAL BENEFIT :

- Employment opportunities; income is earned; and hence improved standards of living.

##### C. SIDE EFFECT:

- Water pollution due to the industrial effluents. These can change the pH of the water or the temperature of the water thus the water becomes unsafe for use and aquatic organisms. This can be mitigated by putting strict laws against dumping of wastes.

### 3. INDUSTRIAL MANUFACTURE OF SOAP (SOAPY DETERGENTS)

#### BY SAPONIFICATION.

##### A. PROCESS OF PRODUCTION:

• A vegetable oil or an animal fat is mixed with concentrated Sodium hydroxide solution in a large stainless steel tank (boiler) and then boiled while stirring until the oil or fat dissolves completely.

• A solution of soap and glycerol is formed.



• The resultant mixture is cooled and then treated with concentrated Sodium chloride solution to precipitate soap. The soap floats and it is skimmed off, washed, and dried.

##### B. SOCIAL BENEFITS:

• Employment opportunities; income is earned; and hence improved standards of living.

##### C. DANGER:

• Water pollution due to the industrial effluents. These can change the pH of the water or the temperature of the water thus the water becomes unsafe for use and aquatic organisms. This can be mitigated by putting strict laws against dumping of wastes.

## 2. INDUSTRIAL MANUFACTURE OF ETHANOL.

### A. PROCESS OF PRODUCTION:

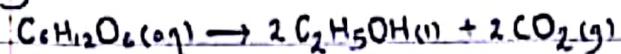
A starch containing substance is crushed and roasted to extract starch.

The starch is mixed with water and malt in a container which is then covered. Malt contains an enzyme called diastase which catalyses the hydrolysis of starch to maltose.

Yeast is then added to maltose after about 5 days:

- The maltase enzyme in yeast catalyses the hydrolysis of maltose to glucose.

- Zymase enzyme in yeast catalyses the breakdown of glucose to crude ethanol and Carbon dioxide.



Crude ethanol is converted to pure ethanol by fractional distillation.

### B. SOCIAL BENEFIT :

Employment opportunities; income is earned; and hence improved standards of living.

### C. SIDE EFFECT :

Water pollution due to discharge of the hot distillation residues into water bodies. These can increase the temperature of the water thus the water becomes unsuitable for aquatic organisms. Mitigation can be done by cooling the distillation residues before discharge.

## 1. INDUSTRIAL MANUFACTURE OF OXYGEN;

### A. PROCESS OF PRODUCTION:

• Air is pumped into tanks and passed through air filters to remove dust and smoke particles.

• Carbon dioxide and water vapour are removed from the air before it is liquefied because they would solidify at low temperatures and block the pipes.

• Air is passed through concentrated Sodium hydroxide solution in scrubbers to remove (absorb) Carbon dioxide.

The Carbon dioxide which is acidic reacts with the Sodium hydroxide to form Sodium carbonate and water.



• Air is then passed through silicon dioxide in the drying column to remove water vapour.

• The air is now compressed at 200 atmospheres in the compression chamber and allowed to cool by making it escape into a large space in the expansion chamber through a jet.

The process of cooling is repeated several times to obtain liquid air at about  $-200^\circ\text{C}$ .

• The liquid air is fractionally distilled using a fractionating column (fractionating tower). Nitrogen boils off first because it has a lower boiling point ( $-196^\circ\text{C}$ ) leaving behind Oxygen with a higher boiling point ( $-183^\circ\text{C}$ ). Both nitrogen and oxygen collected contain traces of noble gases.

• Pure oxygen is then stored under pressure in steel cylinders.

### SOCIAL BENEFIT :

• Employment opportunities; improved income; thus better standards of living.

### SIDE EFFECTS:

• Explosion of oxygen cylinders due to high pressure. This can cause other materials to catch fire. The resulting fire can cause damage to equipment and injury to people.

Mitigation can be done by:

-Regular maintenance and monitoring of cylinders

-Keeping the cylinders in cool areas.