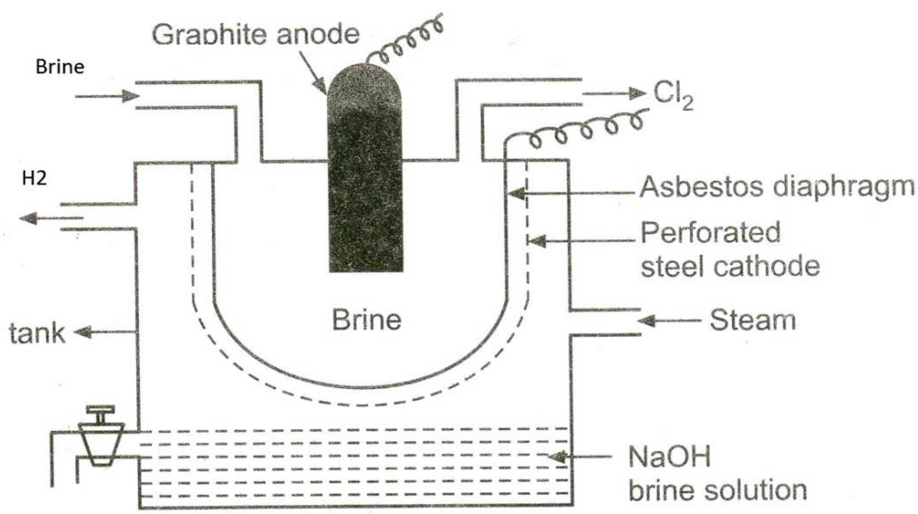
Important Instructions to examiners:

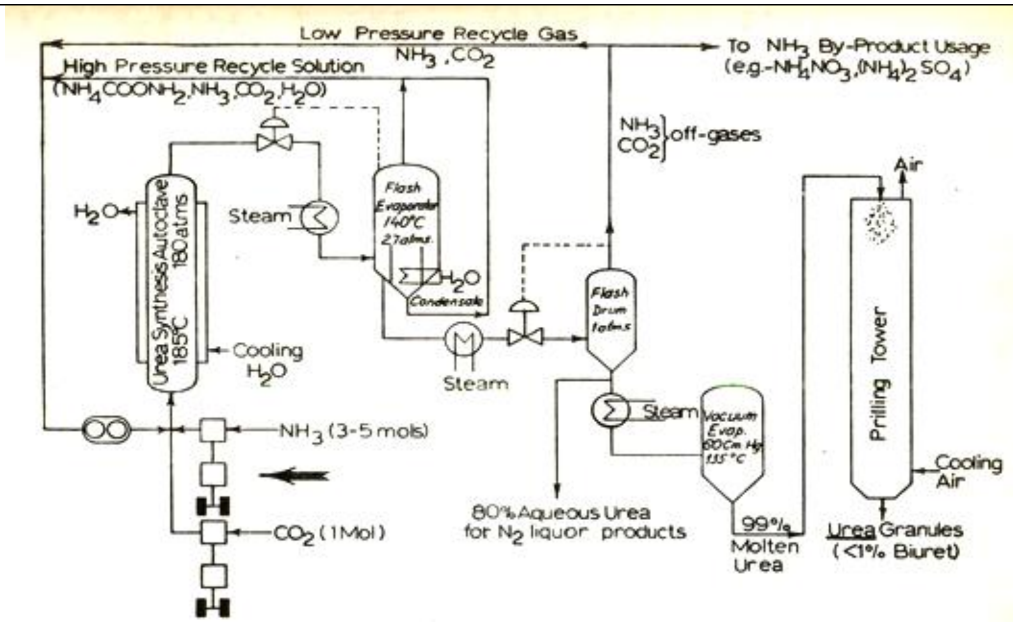
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q No.	Answer	marks	Total marks
Q1 A	**Attempt any six**		**12**
a)	**Catalyst used for sulfuric acid production** • Platinum • Vanidium pentoxide	1 mark each	2
b)	Oleum or **fuming sulfuric acid**, is a solution of various compositions of sulfur trioxide in sulfuric acid.	2	2
c)	**Reactions in sulfuric acid manufacturing** $S + O_2 = SO_2$ $SO_2 + ½ O_2 = SO_3$ $SO_3 + H_2O = H_2SO_4$	2	2
d)	**Properties of sulfuric acid** • Molecular weight: 98 • Melting point 10.5 ^oC • Boiling point 340^oC with decomposition • Completely miscible with water with large heat of solution • Formation of oleum with SO_3 **Uses of sulfuric acid** Production of phosphoric acid, Fetriliser, petroleum refining, concentration of nitric acid.	½ each for any two uses and properties	2
e)	**Catalyst for ammonia production** Iron promoted with K_2O, CaO, SiO_2, and Al_2O_3	2	2
f)	**Cell notation for diaphragm cell**		2

	Anode: $\uparrow Cl_2, C \mid NaCl\ (aq)$ Cathode: $NaOH\ (aq) \mid Fe, H_2 \uparrow$ Cell reaction : Anode : $Cl^- - e^- \rightarrow \frac{1}{2} Cl_2$ Cathode : $Na^+ + H_2O + e \rightarrow Na^+ + OH^- + \frac{1}{2} H_2$ Overall : $NaCl + H_2O \rightarrow NaOH + \frac{1}{2} H_2 + \frac{1}{2} Cl_2$		
g)	**Water gas** is a synthesis gas, containing carbon monoxide and hydrogen	2	2
h)	**Gypsum** $CaSO_4 \cdot 2H_2O$	2	2
Q 1B	**Attempt any two**		**8**
a)	**Nelson cell** 	4	4
b)	**Industrial Fuel Gases** **1. Hydrogen :** As a fuel, feed stock for ammonia, in petrochemical **2. Acetylene :** As a fuel in oxy-acetylene flame, polymer **3. Water gas :** As a fuel, as a source of hydrogen **4. Producer gas** : As a fuel	1 mark each	4

<table>
<tr><td>c)</td><td>Cement
Cement is generic name for powdered material which initially have plastic flow when mixed with water but form a solid structure in several hours with varying degree of strength and binding properties which continue to improve with age.
Portland Cement
<table>
<tr><th>Compound</th><th>Formula</th><th>Shorthand form</th></tr>
<tr><td>Tricalcium aluminate</td><td>$Ca_3Al_2O_6$</td><td>C_3A</td></tr>
<tr><td>Tetracalcium aluminoferrite</td><td>$Ca_4Al_2Fe_2O_{10}$</td><td>C_4AF</td></tr>
<tr><td>Belite or dicalcium silicate</td><td>Ca_2SiO_5</td><td>C_2S</td></tr>
<tr><td>Alite or tricalcium silicate</td><td>Ca_3SiO_4</td><td>C_3S</td></tr>
<tr><td>Sodium oxide</td><td>Na_2O</td><td>N</td></tr>
<tr><td>Potassium oxide</td><td>K_2O</td><td>K</td></tr>
<tr><td>Gypsum</td><td>$CaSO_4.2H_2O$</td><td>$C\underline{S}H_2$</td></tr>
</table>
</td><td>2

2</td><td>4</td></tr>
<tr><td>Q 2</td><td>Attempt any two</td><td></td><td>16</td></tr>
<tr><td>a)</td><td>Urea by Montecatini Process:
Chemical reaction:
i) CO_2(carbon dioxide) + $2NH_3$ (ammonia) → $NH_4.COO.NH_2$ (ammonium carbamate)
ii) $NH_4.COO.NH_2$ (ammonium carbamate) → $NH_2.CO.NH_2$ (urea) + H_2O
iii) Undesirable side reaction :
$NH_2.CO.NH_2$ (urea) → $NH_2.CO.NH.CO.NH_2$ (biuret) + NH_3
Flow diagram :</td><td>Rection-1
Diagram-4
Process-3</td><td>8</td></tr>
</table>

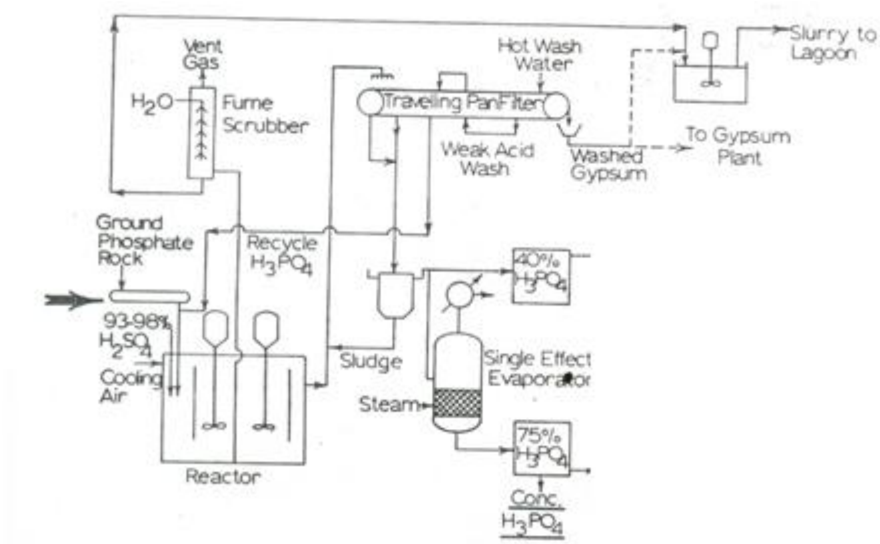


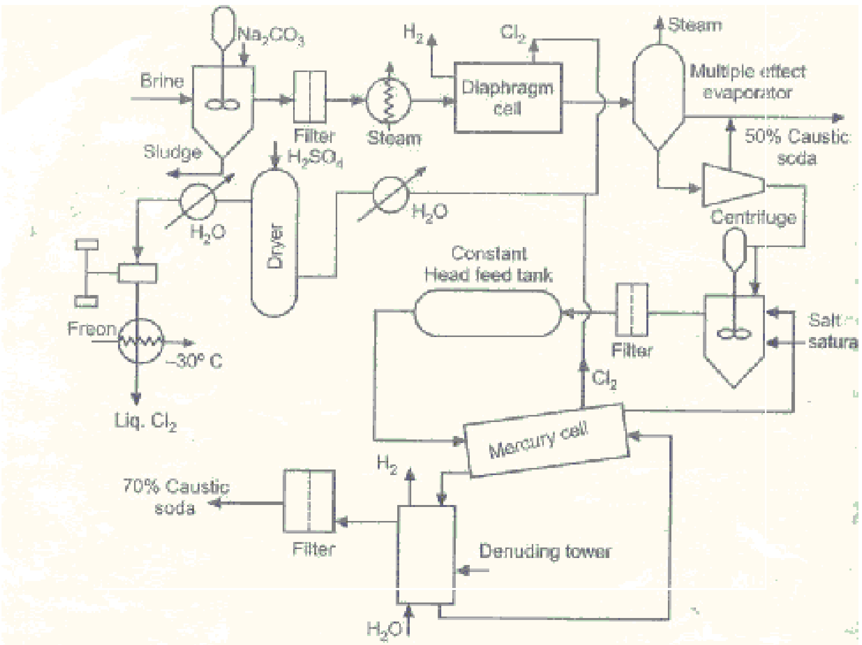
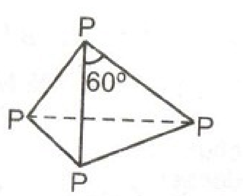
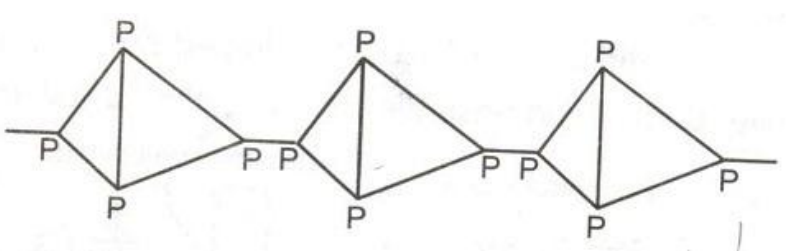
Process description :

Ammonia and carbon dioxide are compressed separately and added to the high pressure autoclave which must be water cooled due to highly exothermic reaction. The average residence time in the autoclave, which is operated on a continuous basis, is 1.5 to 2 hrs. a mixture of urea, ammonium cabamate, water and unreacted NH_3 and CO_2 results.

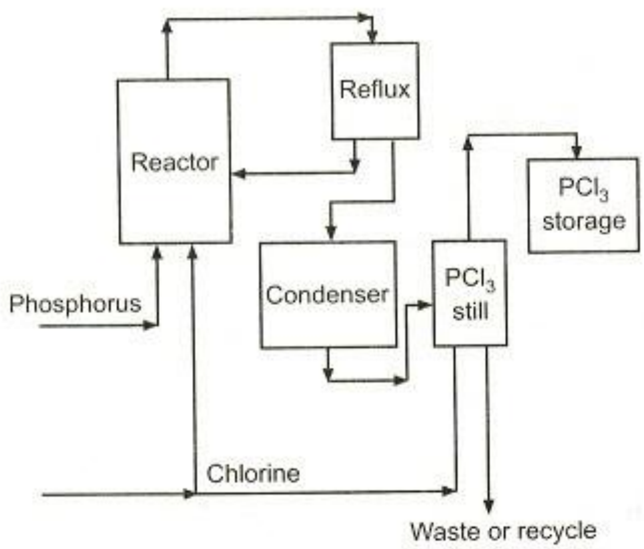
This liquid effluent is let down to 27 atms and feed to a special flash evaporator containing gas liquid separator and condenser. unreacted NH_3, CO_2 and water as a solution are removed and recycled. An aqueous solution of carbamate urea is passed to the atmospheric flash drum where further decomposition of carbamate takes place. The off gases from this step can either be recycled or sent to ammonia process for making chemical fertilizers.

The 80% aqueous urea solution can be used as it is or sent to a vacuum evaporator to obtained molten urea containing less than 1% water. The molten

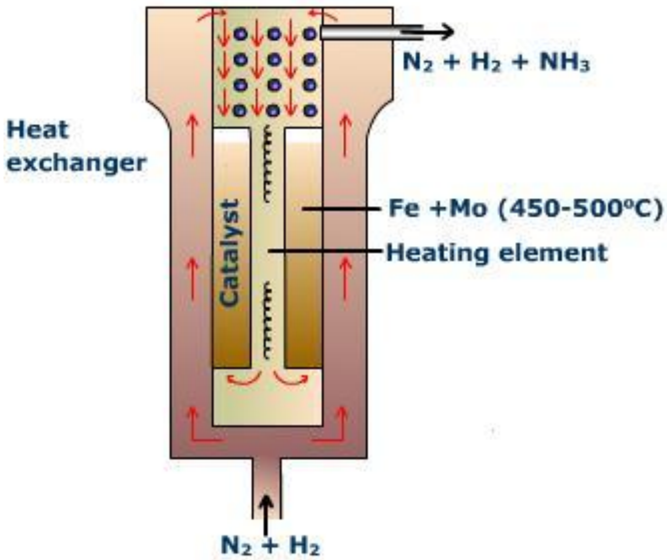
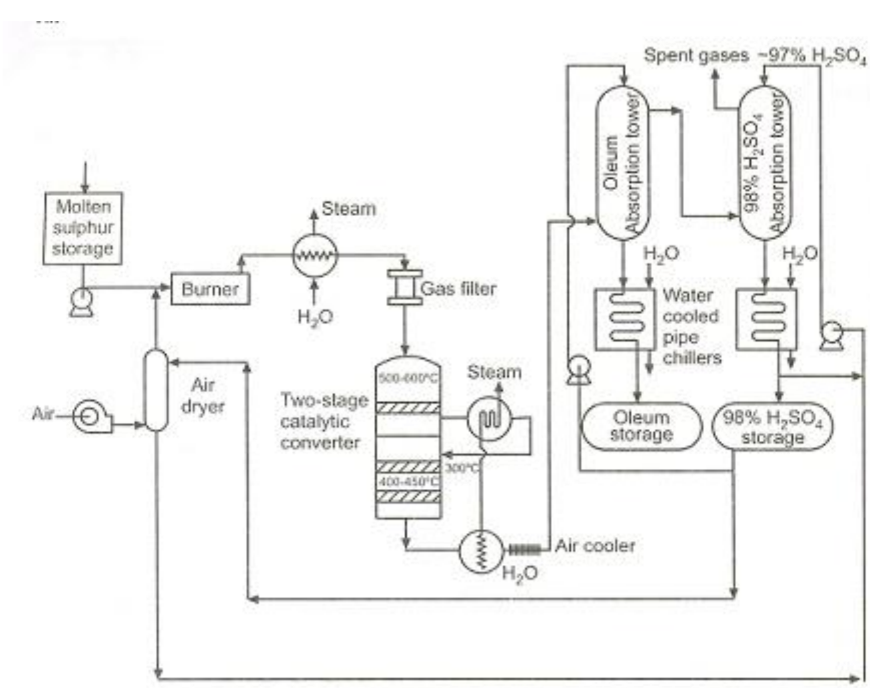
	mass is them sprayed into prilling or granular solidification tower. To avoid formation of biuret in percentage > 1% , the temperature must be kept just above the melting point for processing time of 1-2 seconds in this phase of the operation.		
2-b	**Phosphoric acid** Reaction: $Ca_3(PO_4)_2 + 3H_2SO_4 + 6H_2O = 2H_3PO_4 + 3(CaSO_4.2H_2O)$  1Process: Phosphate rock is ground and fed to chute where a recycle stream of weak phosphoric acid washes into reaction tank. Strong sulfuric acid is fed to the reactor. Around 98% conversion takes in 4-6 hours. Heat of reaction is controlled by using cooling air. Gypsum –Acid slurry is fed to travelling pan filter where 40% acid is removed and cake is washed with water. Filtrate is return to the reactor. The gypsum obtained is dried and send for paint or cement manufacturing. Dilute acid obtained can be concentrated in single effect evaporator.	2 3 3	8

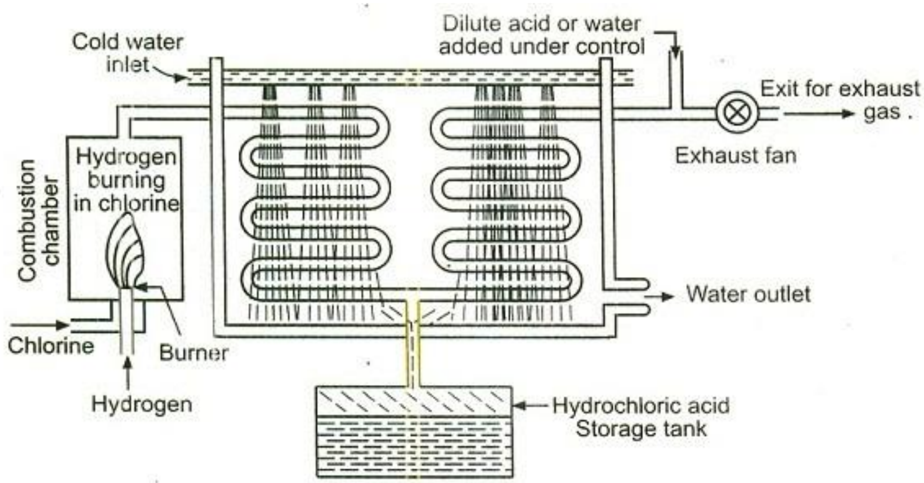
2-c	**Manufacturing Process of caustic soda and chlorine** . 	8	8
Q 3	**Attempt any four**		**16**
a)	**Structure** Yellow phosphorous  Red phosphorous 	1 1	4

	Properties MW =60 MP = 44.1^oC BP = 280 ^oC Stored under water due to reaction with oxygen.	2	
b)	**Electro thermal process:** A mineral phosphate with sand and coke is charged in the electric furnace. It is heated upto 1400 to 1500 ^oC. Initially at 1150^oC, SiO_2 displace more volatile P_2O_5 from calcium phosphate. P_2O_5 is then reducing to phosphorous by coke at 1500^oC. following reaction takes place $Ca_3(PO_4)_2 + 3SiO_2 \rightarrow 3CaSiO_3 + P_2O_5$ $2P_2O_5 + 10C \rightarrow P_4 + 10CO$ $CaSiO_3$ from molten slag is periodically removed through hole. Vapors of Phosphorous and carbon monoxide are send to the tank where cold water is placed. Phosphorous vapors are condensed to white phosphorous and carbon monoxide is escaped.	Rection-1 Process-3	4
c)	**Phosphorous trichloride** is prepared by direct reunion of phosphorus and chlorine, the reaction being exothermic and spontaneous. $P_4 + 6Cl_2 \longrightarrow 4 PCl_3$ Liquid phosphorous and chlorine gas are fed in reactor. PCl_3 formed is partly refluxed in the reflux and a part is passed through a condenser and then to a still for distillation and finally for storage. It is analyzed for elemental phosphorus. Based on this analysis, additional chlorine is introduced to remove traces of unreacted phosphorus.	2	4

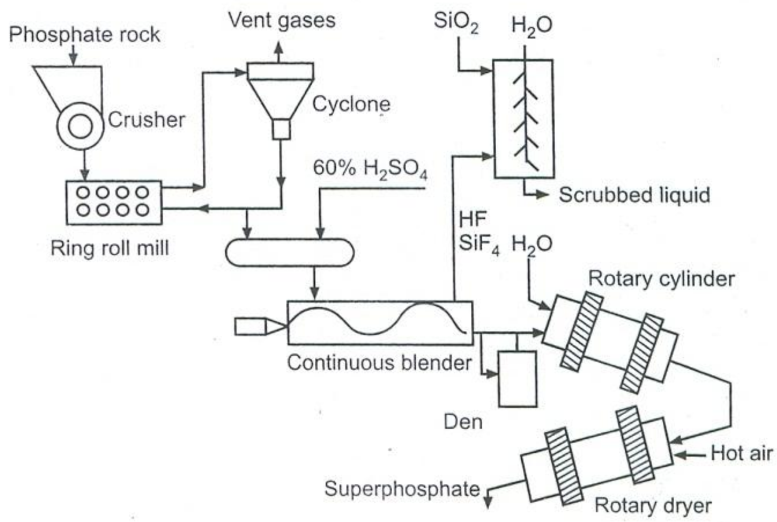
		2	
d)	**Properties of chlorine (any 2)** MW : 35, MP: – 101.5 ^oC, BP : -34.4 ^oC It is a greenish yellow pungent smelling gas and is poisonous in nature. It causes headache if inhaled in small quantities. It dissolves in water to give chlorine water. It can be easily liquefied. It oxidizes, bleaches, disinfects. **Uses of Chlorine(any 2)** 1. Pulp and Paper 2. PVC 3. Chlorinated paraffin wax 4. Pesticides and insecticides 5. Water treatment 6. Rayon grade wood pulp **Properties of caustic soda (any 2)** MW : 40, BP : 1390^oC, MP : 318 ^oC , Very soluble in water with high exothermic heat of reaction.	1 1 1	4

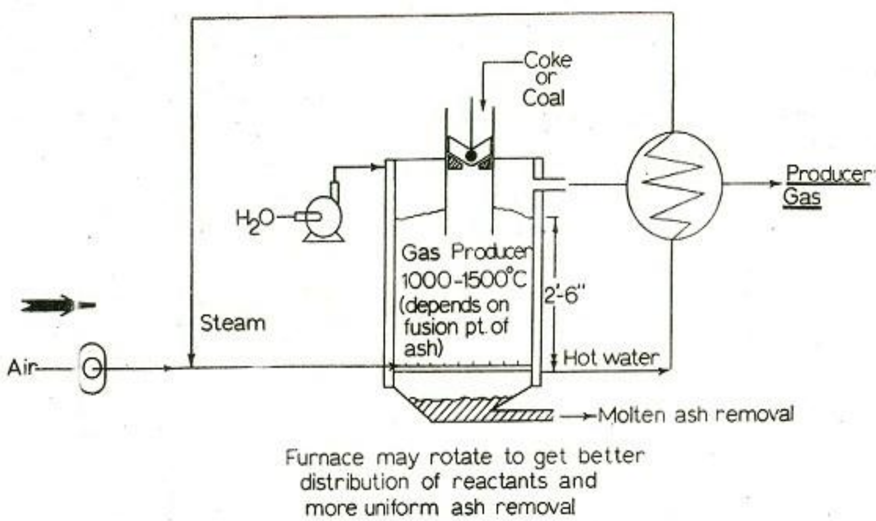
	Uses of Caustic soda (any 2) 1. Textile industry 2. Paper and Pulp 3. Alumina 4. Soap and detergent 5. Dyes	1	
e)	**Ammonia converter.** The gases enter the converter at the base and pass upward round the chamber congaing catalyst Fe + Mo. Then they pass downward through the heat exchanger. The heat exchanger contains several coils of pipe, the mixture of gases get, heated by heat exchange and then passes downwards through the central chamber. It contains heating element. The mixture of gases passes up through the contact chamber congaing catalyst. Finally mixture of gases passes out through the coils of pipe of heat exchanger. It gives most of the heat to the fresh gases on their way to contact chamber. The proportion of ammonia in the coming out from converter is about 10 to 20 % and is remixed by cooling the mixture.	2	4

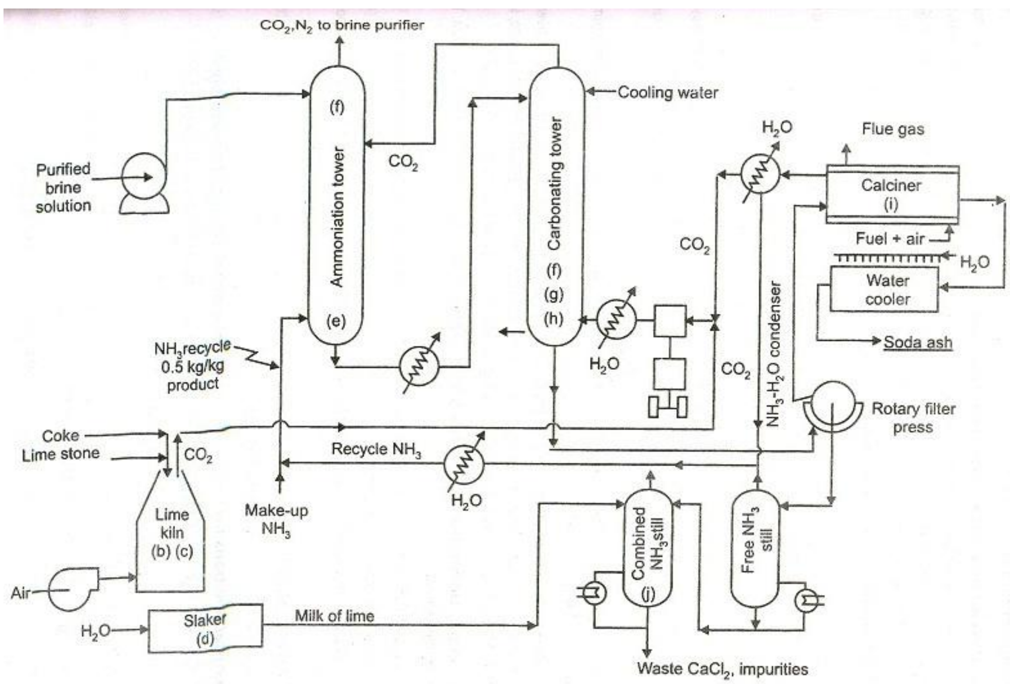
		2	
f)	**Sulfuric acid and oleum production** 	4	4

Q 4	**Attempt any four**		16
a)	**Synthesis process:** The process generates hydrogen chloride by burning chlorine in a few percent excess of hydrogen; chlorine and hydrogen are obtained as by products during manufacture of caustic soda. $H_2 + Cl_2 \longrightarrow 2 HCl$  Dry hydrogen is made to burn in acid resisting burner fitted in a combustion chamber lined with silica bricks. Dry chlorine is passed into the combustion chamber when hydrogen burns in an atmosphere of chlorine to give HCl The gas is passed through a cooler cooled by water spray and then through absorber through which water flows down in controlled quantities. The absorber is also cooled by a spray of cold water to remove the heat of absorption of HCl in water. The solution of HCl flows into storage tank below. An exhaust fan on the extreme right pumps out the waste gases which escape in the atmosphere.	2 2	4
b)	**Plaster of Paris,** quick-setting gypsum plaster consisting of a fine white	2	4

	powder (calcium sulfate hemihydrate), which hardens when moistened and allowed to dry. Known since ancient times, plaster of paris is so called because of its preparation from the abundant gypsum found near Paris. **Uses:** passive fire protection, as fireproofing products Insulation Filler in fertilizer Decorative purpose	2	
c)	**Single super phosphate** Manufacturing of Single Super Phosphate is based on the simplest chemical reaction amongst chemical fertilizers. The major raw materials required are phosphate rock and sulphuric acid. The Rock Phosphate contains Tri Calcium Phosphate which is insoluble in water and hence cannot be taken by the plant. The Rock Phosphate is reacted with dilute Sulphuric Acid. The product of reaction is Mono Calcium Phosphate which is soluble in water. This soluble phosphate can be easily consumed by the plants. Rock phosphate is ground very fine (93% passing through 100 mesh). The measured / weighed quantity of Rock phosphates is fed into lead lined mixer, where it is neutralized with dilute sulphuric acid. The reaction is very fast in the beginning and the material is fine slurry which thickens quickly. The material is discharged in the den where the material slowly solidifies. The den discharge is fitted with den cutter which cuts the solid cake to powder. The Fluorine based gases are liberated which are sucked by ID fan and scrubbed in multi stage conventional scrubbers &venturi Scrubbers. The material gets cured in a few days time. Reaction $[Ca_3(PO_4)_2]_3CaF_2 + 7H_2SO_4 = 3CaH_4(PO_4)_27CaSO_4 +2HF$	2	4

		2	
d)	**Fertilizer** is any organic or inorganic material of natural or synthetic origin (other than liming materials) that is added to soil to supply one or more plant nutrients essential to the growth of plants. Mined inorganic fertilizers have been used for many centuries, whereas chemically synthesized inorganic fertilizers were only widely developed during the industrial revolution. **Inorganic fertilizers** **1. Nitrogen fertilizer :** Urea, Ammonium nitrate, Ammonium sulphate, Ammonium phosphate **2. Phosphorous fertilizer:** Single superphosphate, Triple super phosphate **3. Potassium fertilizer : Potassium chloride, Potassium sulphate**	2 2	4
e)	**Producer gas**, mixture of flammable gases (principally carbon monoxide and hydrogen) and nonflammable gases (mainly nitrogen and carbon dioxide) made by the partial combustion of carbonaceous substances, usually coal, in an atmosphere of air and steam. Steam and air mixture injected in the bottom of water cooled jacket steel	2	4

	furnace equipped with rotating grate to remove fusible ash as shown in figure. Solid fuel is added from hopper valve on the top. Producer gas is cooled by passing through waste heat boiler. 	2	
f)	**CO_2 by fermentation process** Gas from fermenter is send to compressor. With a dry-running piston compressor the fermentation carbon dioxide is compressed to one sixteenth of the original gas volume. After the CO_2 compressor it is send to drying unit . It consists of two adsorption tanks filled with drying agent molecular sieves In order to remove the residual moisture from the gas, the carbon dioxide flows through one tank while the other tank is regenerated by heater. In the gas purifier, installed after the drying unit and also consisting of two vessels, substances influencing odor and taste are removed. By compression and condensation the storage volume is reduced to such an extent that temporary storage of even very large quantities of carbon dioxide requires little space. The compressed gas is liquefied in the condenser and then collected in a storage	4	4

	tank		
Q5	**Attempt any two**		**16**
a)	**Solvay process** The overall reaction can be regarded as between calcium carbonate and sodium chloride: $CaCO_3 + 2NaCl \longrightarrow CaCl_2 + Na_2CO_3$ However, calcium carbonate is too insoluble to react with a solution of salt. Instead the product is obtained by a series of seven stages.  The process is known as the ammonia-soda process or the Solvay process, named after the Belgian industrial chemist who patented it in 186I. The various stages of the Solvay process are interlinked as can be seen from the diagram and description below.	Rection-2 Diagram-3 Process-3	8

	(1) Ammoniation of brine Ammonia gas is absorbed in concentrated brine to give a solution containing both sodium chloride and ammonia. Na^+(aq), Cl^-(aq), NH_4^+(aq), OH^-(aq) ions and NH_3(aq) are present. **(2) Formation of calcium oxide and carbon dioxide** Kilns are fed with a limestone/coke mixture (13:1 by mass). The coke burns in a counter-current of pre-heated air: $C(s) + O_2(g) \longrightarrow CO_2(g) \quad \Delta H^\ominus = -393 \text{ kJ mol}^{-1}$ The heat of combustion raises the temperature of the kiln and the limestone decomposes: $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \quad \Delta H^\ominus = +180 \text{ kJ mol}^{-1}$ The gas, containing approximately 40% carbon dioxide, is freed of lime dust and sent to the carbonating (Solvay) towers. The residue, calcium oxide, is used in ammonia recovery (see step 7 below). **(3) The Solvay Tower** This is the key stage in the process. The ammoniated brine from step (1) is passed down through the Solvay Tower while carbon dioxide from steps (2) and (5) is passed up it. The Solvay Tower is tall and contains a set of mushroom-shaped baffles to slow down and break up the liquid flow so that the carbon dioxide can be efficiently absorbed by the solution. Carbon dioxide, on dissolving, reacts with the dissolved ammonia to form ammonium hydrogencarbonate: $NH_3(aq) + H_2O(l) + CO_2(g) \longrightarrow NH_4HCO_3(aq)$ The solution now contains ions Na^+(aq), Cl^-(aq), NH_4^+(aq) and HCO_3^-(aq). Of the four substances which could be formed by different		

combinations of these ions, sodium hydrogencarbonate ($NaHCO_3$) is the least soluble. It precipitates as a solid in the lower part of the tower, which is cooled. The net process is:

$$NaCl(aq) + NH_3(aq) + H_2O(l) + CO_2(g) \longrightarrow NaHCO_3(s) + NH_4Cl(aq)$$

A suspension of solid sodium hydrogencarbonate in a solution of ammonium chloride is run out of the base of the tower.

(4) Separation of solid sodium hydrocarbonate

The suspension is filtered to separate the solid sodium hydrogencarbonate from the ammonium chloride solution, which is then used in stage (7).

(5) Formation of sodium carbonate

The sodium hydrogencarbonate is heated in rotating ovens at 450 K so that it decomposes to sodium carbonate, water and carbon dioxide:

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

The carbon dioxide is sent back to the Solvay Tower for use in step (3). The product of the process, anhydrous sodium carbonate, is obtained as a fine white powder known as light sodium carbonate.

(6) Formation of calcium hydroxide

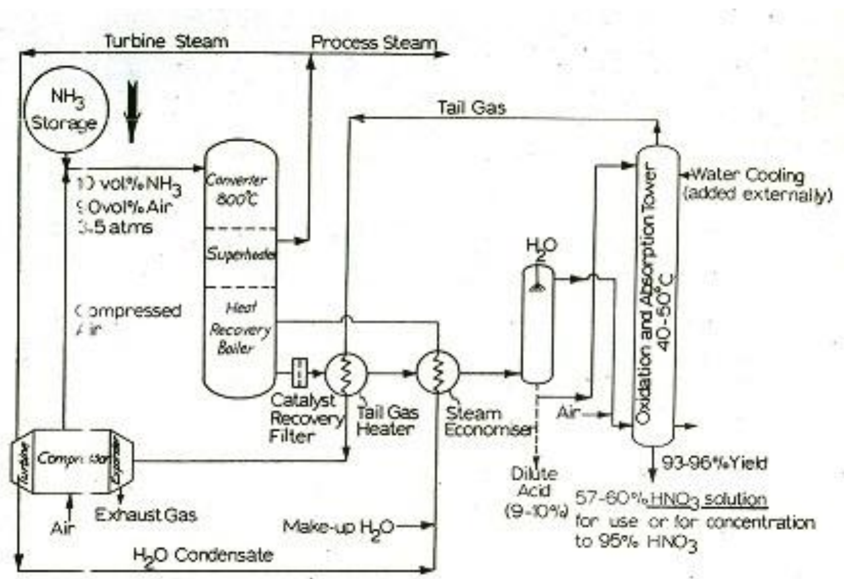
The last two stages, (6) and (7), are concerned with the regeneration of ammonia from ammonium chloride (made in step 3). The quicklime from step (2) is slaked with excess water giving milk of lime:

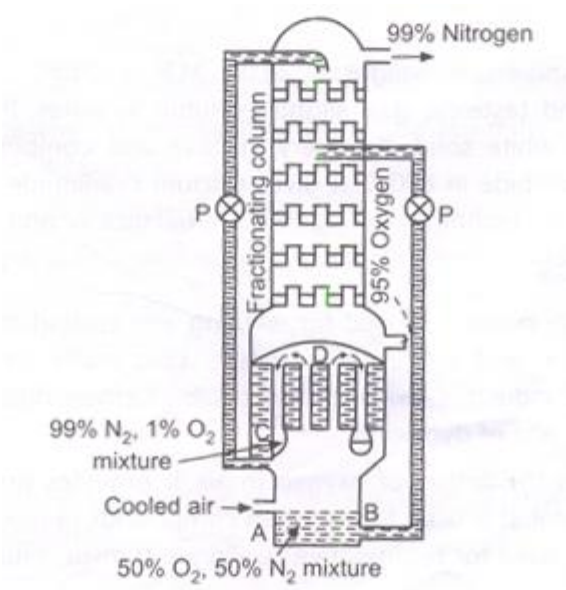
$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq/s)$$

(7) Regeneration of ammonia

This calcium hydroxide suspension is mixed with the ammonium chloride solution left from step (4) and heated:

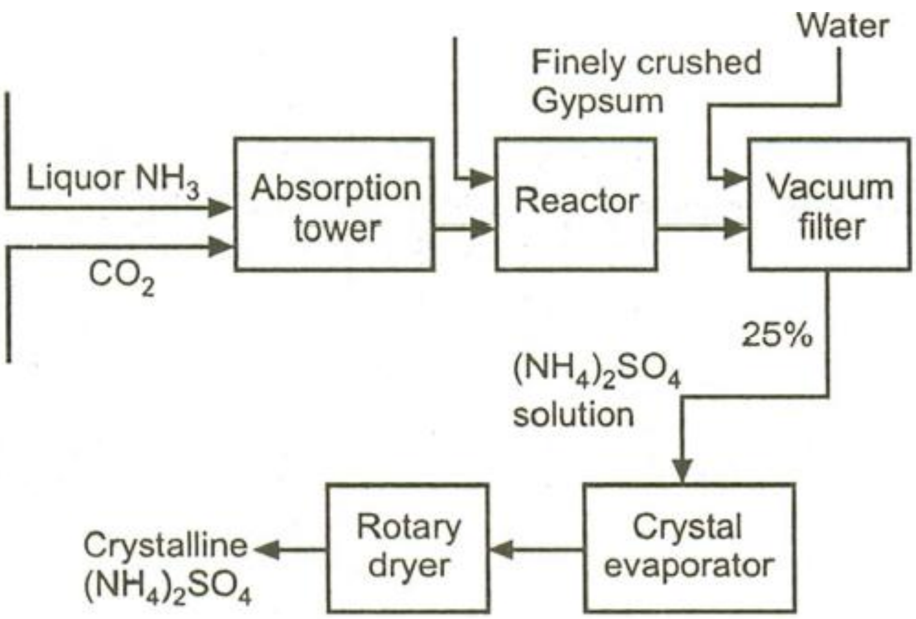
$$2NH_4Cl(aq) + Ca(OH)_2(aq/s) \longrightarrow CaCl_2(aq) + 2NH_3(g) + 2H_2O(l)$$

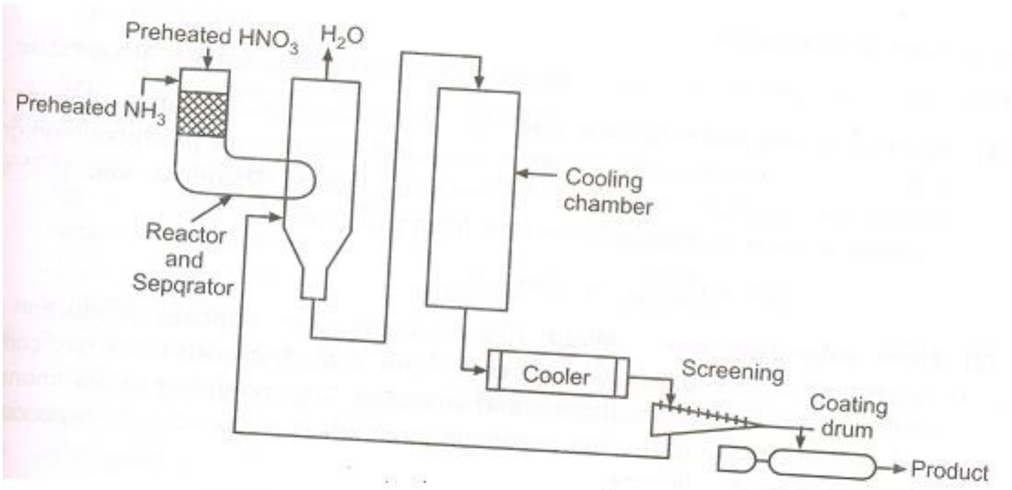
	The ammonia is thus recovered, and sent back to step (1). Calcium chloride is the only by-product of the whole process. The overall process is an elegant one. In theory, the only raw materials are limestone and brine. Inevitably, there are losses of ammonia, and these are made up for by addition of extra supplies, as required in step (1)		
b)	**Nitric Acid Production** Raw material Ammonia, air, water Reaction $4NH_3+5O_2 = 4NO +6H_2O$ $2NO+O_2 = 2NO_2$ $3NO_2+H_2O=2HNO_3+NO$  Ammonia and air are compressed and send to the catalytic converter. Ammonia is oxidized and converted into nitric oxide. Large heat is evolved which can de utilized to run turbine by producing steam and gas expander. Both are connected to the compressor. Hence compressor does not require external	Rection-2 Diagram-3 Process-3	8

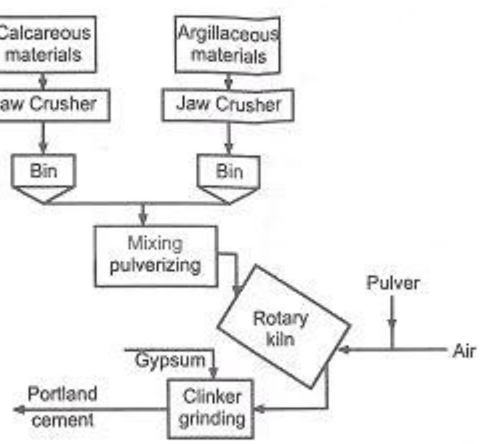
	energy source. NOx gases after heat recovery is send through cooler condenser where it is cooled by cooling tower water. Some part of acid is converted into liquid form. Both liquid and gas are send to absorption tower at different feed plates. Air is provided from the bottom to complete oxidation of NO. Water is fed from the top of the tower. Nitric acid (60%) is collected at the bottom. Tail gases from the absorber are used to run gas expander after heating.		
c)	**CLAUDES PROCESS:** Principle: when a cooled compressed gas is allowed to some external work e.g. pushing the piston of gas engine, it falls in temperature. Flow diagram:  Process description: Air freed from CO_2 is dried, compressed and passes through a pipe surrounded by cold oxygen and nitrogen, where it is cooled. Cooled and compressed air is allowed to do work in an expansion engine where it is further cooled. This cooled air enters the plant and rises through iron tubes surrounded by	2 3	8

	liquid oxygen. a part of the air gets liquefied and collects. the condensation is 50% N2,50%O2 .the gas which escape condensation passes downwards through side tubes surrounded by liquid oxygen and condenses. The condensation being 99% N_2 and 1% O_2 The condensed liquid is pumped to the top of fractionating column, while the bottom liq. Is pumped to a level slightly above the fractionating column, where it meets an upward current of gases. the liq is wormed up a little as it comes down and loses a volatile constituents more and more. i.e. N_2 bye evaporation and gets gradually richer in O_2 . similarly up going gases loses more and more O_2 by condensation due to cooling and gets richer in N_2.by the time gases rich the top, it is 99% pure N_2 which escape to the exit provided. Liq O_2 evaporate as it cools the air and escape to the exit indicated	3	
Q6	**Attempt any four**		**16**
a)	**Acetylene from CaC_2** Raw materials: lime stone, coke, water Chemical reactions: $CaO + 3C \rightarrow CaC_2 + CO$ $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + CH{\equiv}CH$ $CaCO_3 \longrightarrow CaO + CO_2$ $2CO + O_2 \rightarrow 2\ CO_2$ Process Description: Calcium carbide is produced by heating lime and coke in an electric furnace at 2100 ˚C . Molten CaC_2 is solidified and cooled and ground under nitrogen In the wet process the pulverized carbide is fed through a gas tight hopper to a C2H2 generator in which the quality of water used is sufficient to discharge $Ca(OH)_2$. The carbide is fed to water at a measured rate until exhausted. Calcium hydroxide slurry containing 90% water is discharged. The gas is passes through a scrubber to remove impurities like NH_3, sulphides, phosgene	Mark should be given for any method 1 3	4

	and finally through a purifier containing iron oxide and alumina or silica gel. The temperature in the gas generator is kept below 90˚C and a pressure of 2 atm. In a dry process equal weights of the quantities H_2O and CaC_2 are used in the generator to eliminate waste disposal problem of lime slurry. The heat of reaction is largely dissipated by water vaporization leaving by product lime in dry state. The dry process is more dangerous because of the temperature control in the generator. Acetylene polymerizes at 250˚C and above and decomposes violently at 650˚C . Hence temperature is maintained below 150˚C and 30 cm of water pressure.		
b)	**Water Gas (continuous process):** Raw materials: Steam, coal, oxygen Reactions: $C + O_2 \longrightarrow CO_2$ $C + H_2O \longrightarrow CO + H_2$ Process description: This process was invented in 1940 by Germans. This process is based on use of tonnage or low purity grade oxygen made by air separation procedure. The correct ratio of steam, oxygen and coal is added to the reactor to yield a self-sustaining reaction of approximately zero heat release. Subsequent innovations allow for ash content >30% so Indian coal can be used in this process	2 2	4
c)	**Ammonium sulfate** $2NH_3 + CO_2 + H_2O \rightarrow (NH_4)_2CO_3$	4	4

	$(NH_4)_2CO_3 + CaSO_4.2H_2O \rightarrow (NH_4)_2SO_4 + CaCO_3 + 2H_2O$ 		
d)	**Ammonium Nitrate** **Process description** – In the Stengel process, vapours of ammonia & nitric acid are mixed in a stainless steel reactor. The reaction is exothermic & hence heat is given out. The mixture of steam & molten ammonium nitrate is fed to cyclone type separator. The molten mass is solidified on the water cooled stainless steel belts .Then material is passed to a grinder where is the material is crushed dried and ground to flake size then, ammonium nitrate flakes are coated with clay.	2	4

		2	
e)	**Phosphorous** Raw material: Phosphate rock, coke, sand Reaction: $2Ca_3(PO_4)_2 + 10C + 6SiO_2 = P_4\,(Yellow) + 6\,CaSiO_3 + 10CO$ P_4 (Yellow) + heating = P_4 (Red) Phosphate rock is ground, mixed with portion of coke requirement, then sintered into nodules to obtain better electrical resistivity characteristics and to avoid entrainment of fines in the released phosphorous and carbon monoxide vapors. Screening is necessary to maintain size control with fines recycled to the sintering operation. Coke breeze and sand particles are mixed in controlled quantities based on phosphate rock analysis. The electrical 3 phase furnace is at 230-300V designed with power fed to 100-150cm diameter carbon electrode on each phase. The feed charge drops gradually into the fused section of the furnace at 1400^{o}C where the reduction to elemental phosphorous takes place. The furnace is kept under slight vacuum by fans in the downstream end of the plant, so the furnace gases moves to	1 3	4

	electrostatic precipitator to remove dust and then water cooled condenser. Liquid yellow phosphorous is collected under water. CO obtained is used as fuel. Molten slag obtained from furnace can be used as raw material for furnace.		
f)	**Dry process for Portland cement:** The dry process is used when the raw material is either cement rock or blast furnace slag. The calcareous raw material and argillaceous are crushed separately by jaw or roller crusher(primary crushing) The material is dumped to huge bins The raw material is mixed by automatic weighing machines then it is fed to grinding mill, pulverized then to rotary kiln . Rotary kiln is 50-80m long and having three times diameter kiln is inclined and rotate one revolution per minute. Temperature maintained in the kiln is 1400-1500^o C . The product obtained is known as clinker removed from the lower end of the kiln then ground with 2% gypsum to obtained Portland cement.  	2 2	4