Summer-18 EXAMINATION

Model Answer

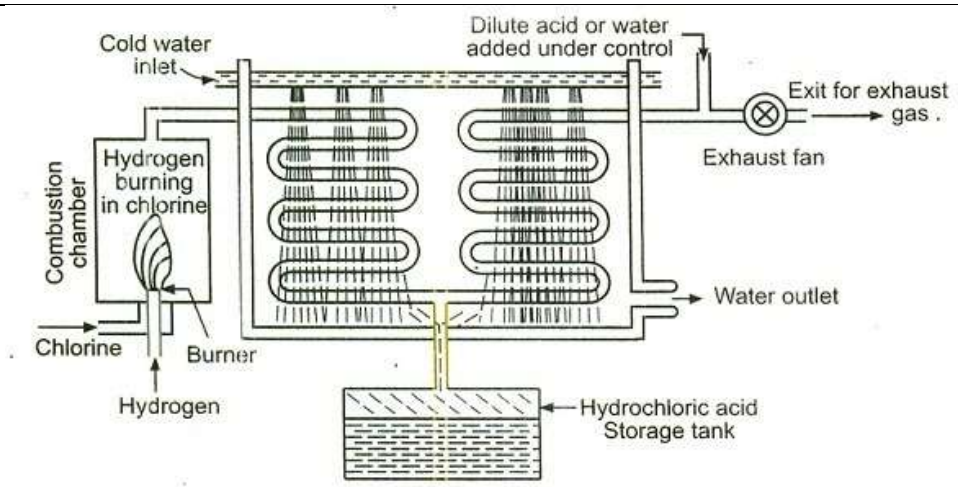
Subject Title: Chemical process Technology-1 Subject code : 17314

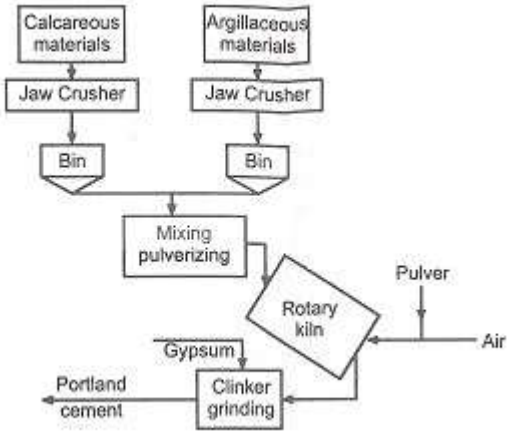
Important Instructions to examiners:

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 one quivalent concept.

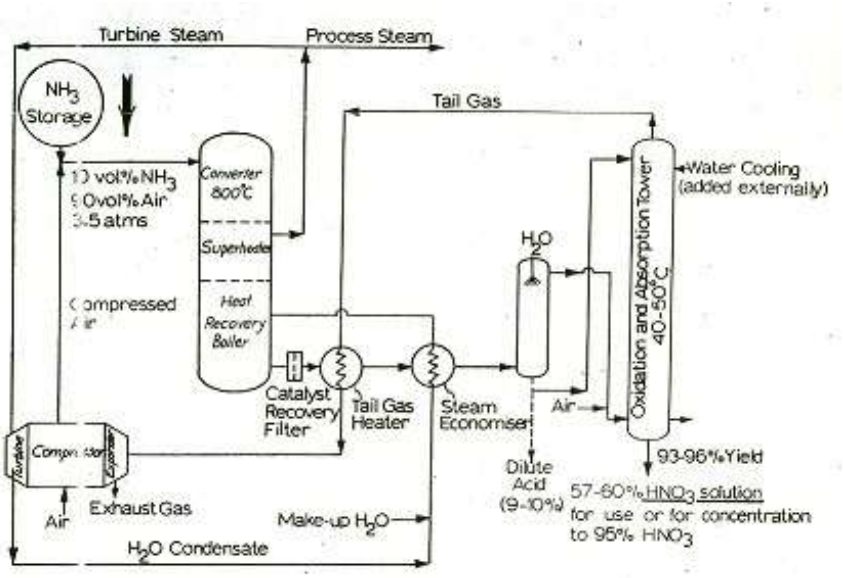
Q No.	Answer	Marks
1A	**Attempt any six**	12
a)	**Uses of sulfuric acid (any four)** a) For manufacturing of Fertilizers b) Oil refining c) Metal processing d) Manufacturing of Rayon e) In Lead acid batteries f) Detergent manufacturing	½ mark each for any four
b)	**Raw material for sulfuric acid production** 1. Air 2. Sulfur 3. Water	2
c)	**Sulfuric Acid absorption** If SO_3 dissolved directly in water, then a large amount of heat is evolved. This heat gives a dense form of minute particles of H_2SO_4. These particles do not easily condense down. Hence it is absorbed in conc. Sulfuric acid.	2
d)	**Properties of sulfuric acid: (any 4)** • 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	½ mark each for any four
e)	**Merits of contact process** • Yield of sulfuric acid is more	1 mark each

	• Contact process can produce high concentrated sulfuric acid • It reduces emission of SO_2.	for any two
f)	**Uses of ammonia(any 4)** 1. For production of urea 2. For production of nitric acid 3. For production of ammonium nitrate 4. For production of ammonium phosphate 5. As refrigerant 6. In food industry	½ mark each for any four
g)	**Methods for cement production** 1. Dry Process 2. Wet Process	1 mark each
h)	**Cell notation for diaphragm cell** 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 : $NaCl + H_2O \rightarrow NaOH + \frac{1}{2} H_2 + \frac{1}{2} Cl_2$	2
1B	**Attempt any two**	**8**
a)	**Synthesis process for HCl** (diagram and raw material) Raw material 1. Hydrogen 2. Chlorine	1

	 3.	3
b)	**Claudes Principle** When a cooled compressed gas is allowed to some external work e.g. pushing the piston of gas engine, it falls in temperature. **Lindes Principle** The principle underlying is joule – Thomson effect which states that when a gas under pressure is allowed to expand suddenly through a small orifice into a region of low pressure it falls in temperature.	2 2
c)	**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	2

	obtained is known as clinker removed from the lower end of the kiln then ground with 2% gypsum to obtained Portland cement.  	2
2	**Attempt any two**	**16**
a)	**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 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	2 3

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. — 3



b) **Triple superphosphate** — 2

This material is much more concentrated fertilizer then ordinary superphosphate it contains from 45 to 46% of available P2O5 of nearly three times the amount in the regular superphosphate.

Chemical reaction:

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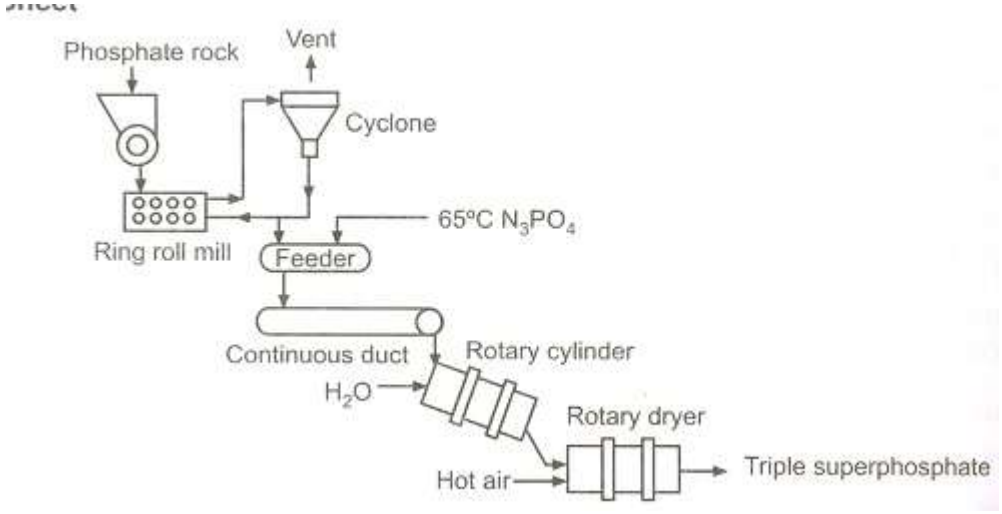
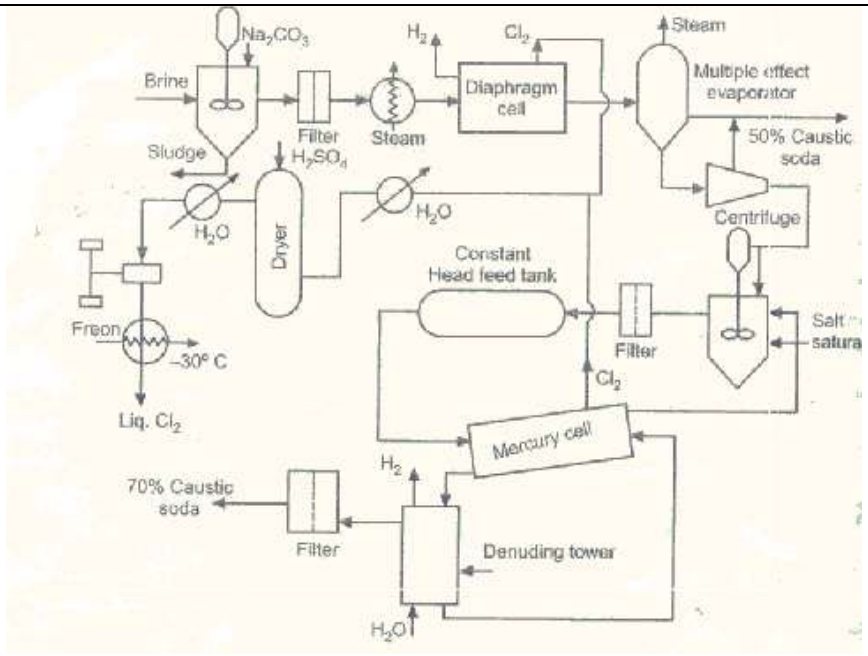
$$CaF_2.3Ca_3(PO_4)_2 + 14H_3PO_4 \longrightarrow 10Ca(H_2PO_4)_2 + 2HF$$

It is made by action of phosphoric acid on phosphate rock. The pulverized phosphate rock is mixed with phosphoric acid into a two stage reactor. The

	resultant slurry is sprayed into the granulator The product from the granulator is dried, screened, the oversize crushed and cooled again. Final product is conveyed to bulk storage where product is cured 4 to 6 weeks. During curing further reaction of acid and rock occurs which increases the availability of P_2O_5 for plants as food. Exhaust gases from granulator and cooler are scrubbed with water to remove silicofluorides.  	4
c)	**Manufacturing Process of caustic soda and chlorine** Process description- Purified saturated brine is heated and electrolyzed in a diaphragm cell. The cell operating at 45-55% decomposition efficiency, discharges 10-12% solution of caustic soda with about equal concentration of NaCl. Multiple effect evaporator concentrates the cell liquor to 50% NaOH solution The opted salt is separated, centrifuged, washed, then slurried with treated brine. Salt saturator overflow is 50% caustic soda product. This further brine is again treated the mercury cell and the yield from this section is 70% of caustic soda. Chlorine is collected, dried, compressed and cooled upto-30^{o}C and collected as liquid chlorine	4



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Or

Electrolytic Process:

In this process carbon dioxide is passed in the solution of sodium hydroxide obtained by the electrolysis of aqueous solution of sodium chloride.

4

$2NaOH + CO_2 \longrightarrow Na_2CO_2 + H_2O$

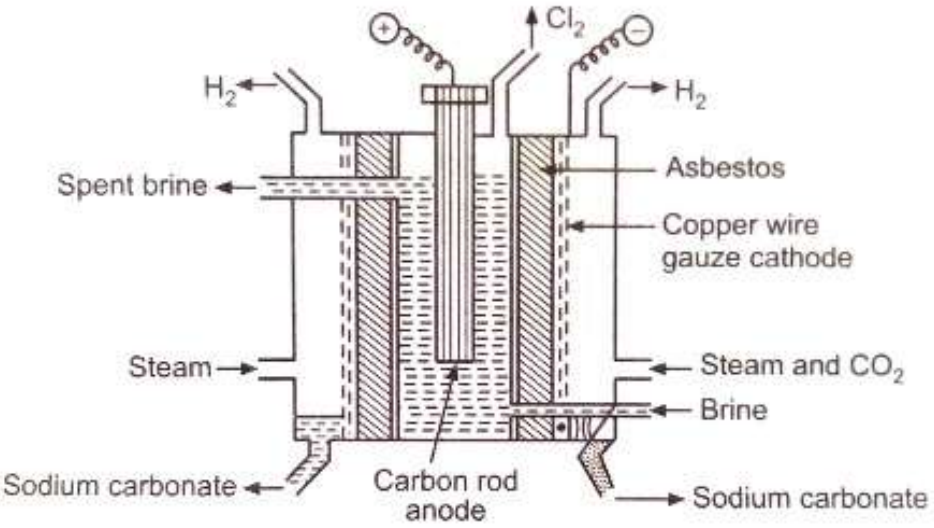
The electrolysis of sodium chloride is carried in an iron box lined with bricks. A carbon rod is used as the anode and copper wire gauze covered on the inside with asbestos serves as the cathode.

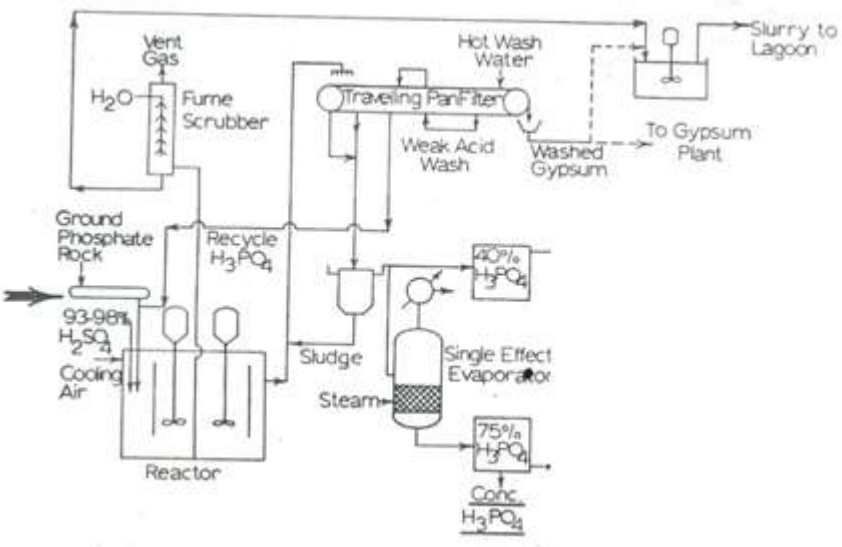
A concentrated solution of sodium chloride is admitted into the cell at the bottom and the electrical current is passed through it. As the solution rises it undergoes electrolysis and finely leaves the cell from the top as spent liquor.

$2NaCl \longrightarrow 2Na^+ + 2\ Cl^-$

At cathode, $2H_2O + 2e^- \rightarrow 2OH^- + H_2$

At anode, $2\ Cl^- \longrightarrow Cl_2 + 2\ e^-$

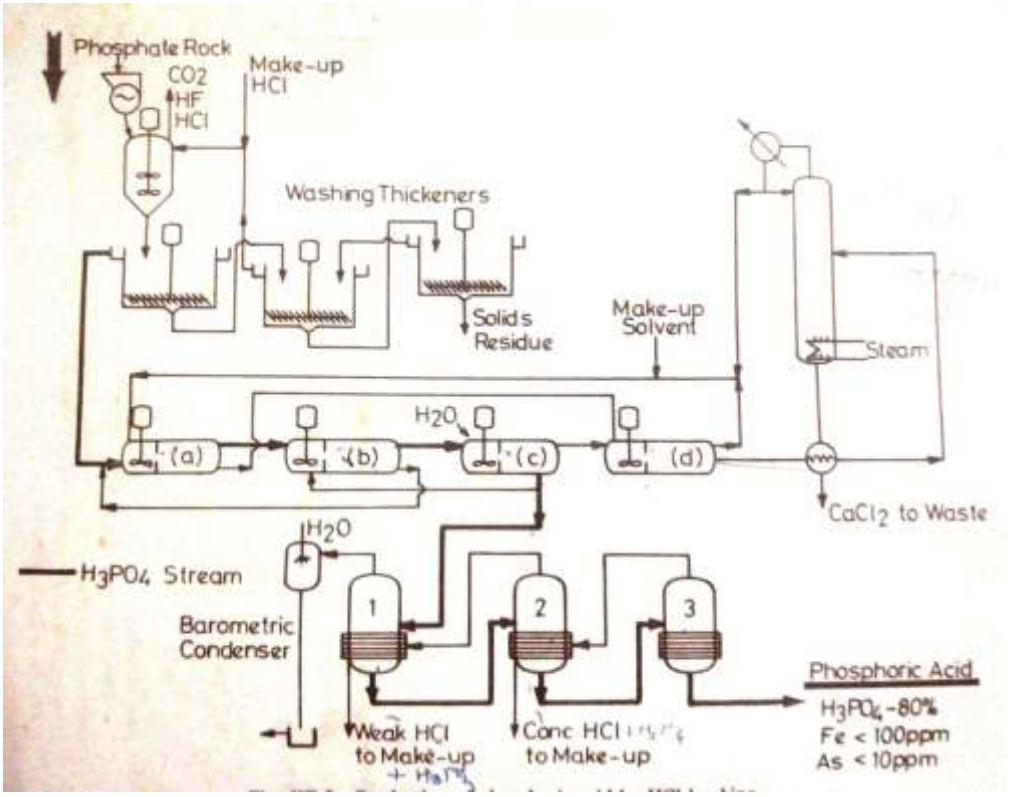
	Thus chlorine is liberated at the anode and at the cathode sodium hydroxide and hydrogen are formed. Chlorine and hydrogen escapes from the respective outlets in the anode and cathode compartments. A mixture of steam and carbon dioxide is then blown into the sodium hydroxide solution in the cathode compartment when sodium carbonate is formed as mentioned earlier. The solution is periodically removed and concentrated to obtain pure crystalline sodium carbonate.  	4
3	**Attempt any four**	**16**
a)	**Difference between yellow and red phosphorous** **Yellow phosphorus** / **Red phosphorus** Melting point = 44.1 ^oC / Melting point = 593 ^oC Ignite spontaneously in air / Higher resistance to oxidation Highly toxic / Comparatively Less toxic Lesser denser / Higher Denser	One mark each for any four

		Used for the production of P_2O_5 and phosphoric acid	Used in safety matches, tracer bullets, incendiary devices, pesticides, pyrotechnic devices	
b)	**Phosphoric acid by wet process** **1. H_2SO_4 leaching** Reaction: $Ca_3(PO_4)_2 + 3H_2SO_4 + 6H_2O = 2H_3PO_4 + 3(CaSO_4.2H_2O)$  Process: 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 2

OR

2. HCL leaching

Phosphate rock is ground and HCl is added in it. Fumes of CO_2, HF and HCl are scrubbed for acid recovery. The mixture is fed to series of decanter and settlers and then to counter current solvent extraction operations. The solids underflow goes to 2-3 washing thickeners. Extraction of phosphoric acid and some free HCl is done in an battery of mixer –settlers with $CaCl_2$ retain in aqueous phase. The extract is passed through several more mixer settlers. Phosphoric acid is recovered in triple effect evaporator and $CaCl_2$ is separated from final settler. — 2



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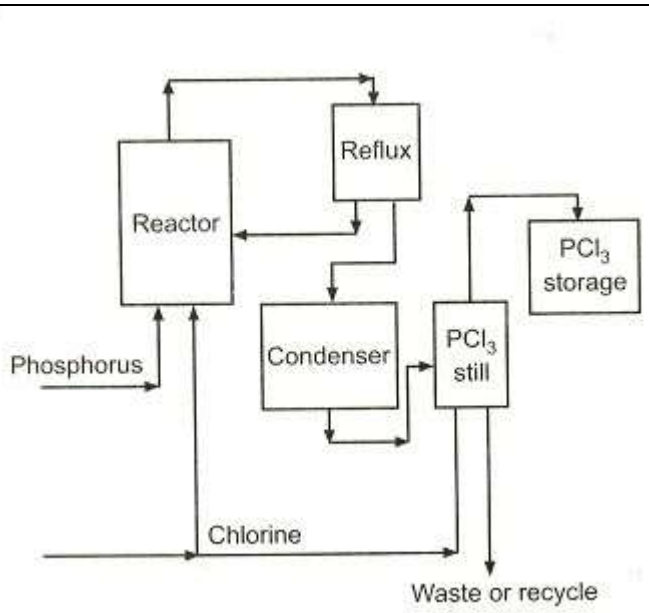
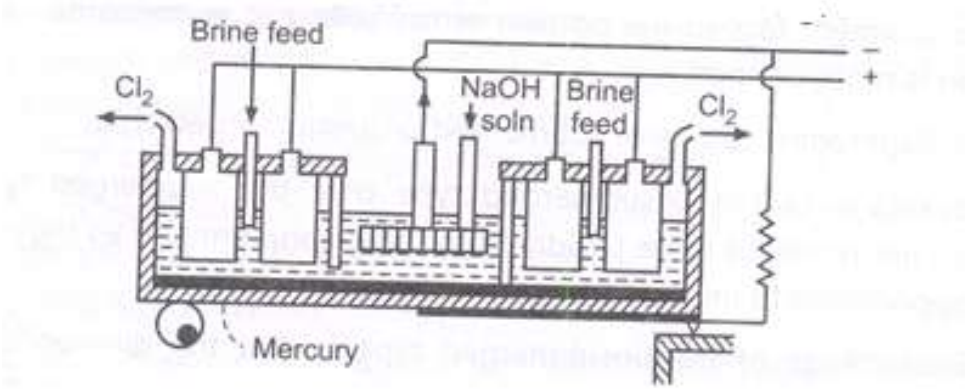
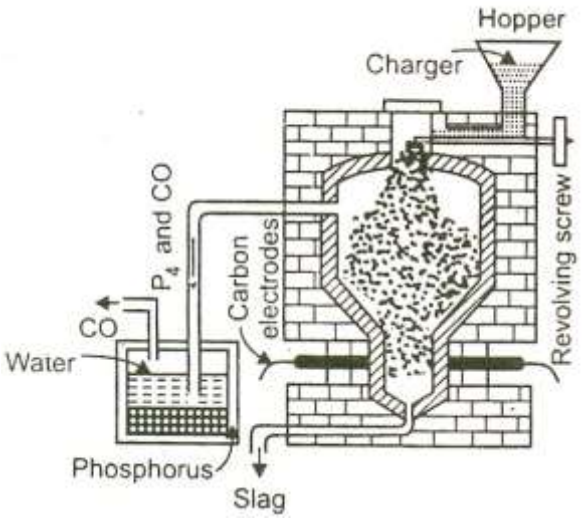
c) **Phosphorous trichloride (PFD and Reaction)**

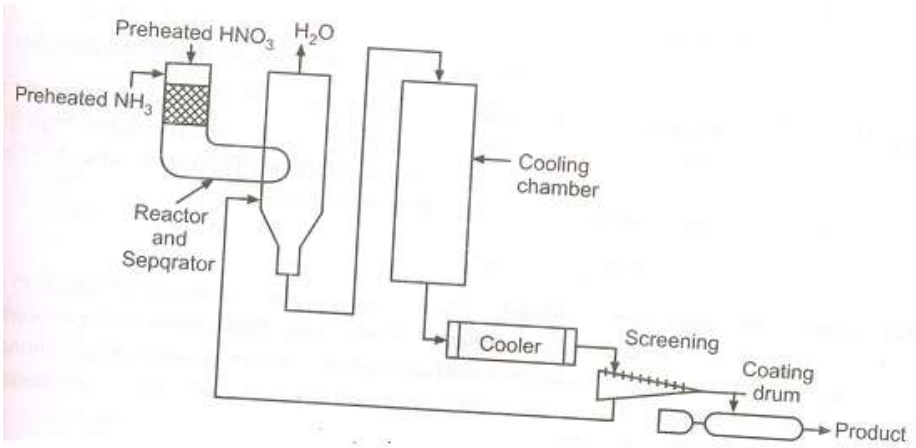
	 $P_4 + 6Cl_2 \longrightarrow 4\ PCl_3$	3 1
d)	**Mercury Cell** 	4
e)	**Properties of chlorine (any 2)** MW : 35, MP: – 101.5 ^oC, BP : -34.4 ^oC It is a greenish yellow pungent smelling gas and is poisonous in nature. It causes headache if inhaled in small quantities. It dissolves in water to give	1

	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^{o}C, MP : 318 ^{o}C , Very soluble in water with high exothermic heat of reaction. **Uses of Caustic soda (any 2)** 1. Textile industry 2. Paper and Pulp 3. Alumina 4. Soap and detergent 5. Dyes	1 1 1
f)	**Use of soda ash** • Glass manufacturing • Soap/detergents • Pulp and paper • Desulfurization • Textile processing	1 mark each for any four
4	**Attempt any four**	**16**
a)	**Sodium Carbonate:** Raw materials: Salt(brine), coal, limestone	1

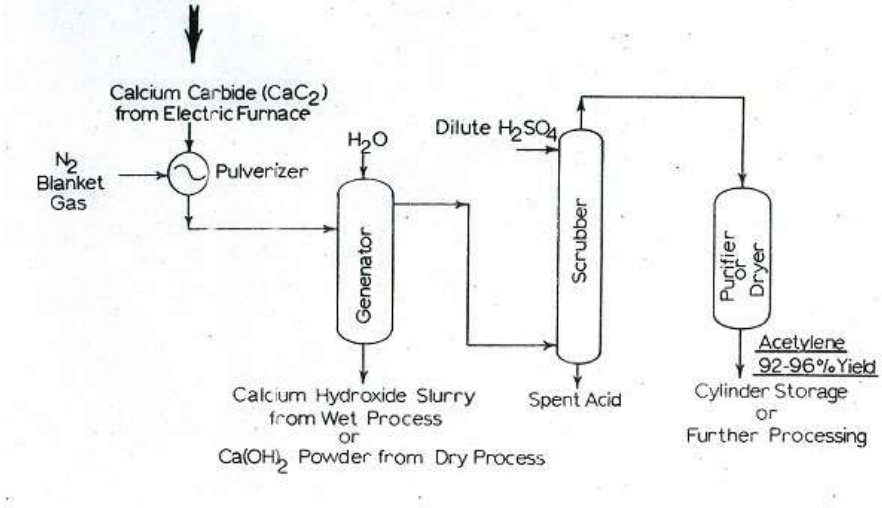
	Chemical Reactions: Main reaction is $CaCO_3(s) + 2NaCl\ (aq) = Na_2CO_3 + CaCl_2$ This reaction takes place in a number of steps : (b) $CaCO_{3\,(s)} \longrightarrow CaO_{(s)} + CO_{2\,(g)}$; (c) $C_{(s)} + O_{2\,(g)} \longrightarrow CO_{2\,(g)}$; (d) $CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2\,(aq)}$; (e) $NH_{3\,(g)} + H_2O \rightleftharpoons NH_4^+ + OH^-$; (f) $CO_{2\,(g)} + OH^- \rightleftharpoons HCO_3^-$ (g) $CO_{2\,(g)} + H_2O \rightleftharpoons HCO_3^- + H^+$ (h) $Na^+ + Cl^- + NH_4^+ + HCO_3^- \longrightarrow NH_4^+Cl^-_{(aq)} + NaHCO_3\downarrow$ (i) $2NaHCO_{3\,(s)} \longrightarrow Na_2CO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(g)}$; (j) $2NH_4Cl_{(aq)} + Ca(OH)_{2\,(s)} \longrightarrow 2\,NH_{3\,(g)} + CaCl_{2\,(aq)} + 2\,H_2O_{(l)}$	3
b)	**Conversion of Yellow Phosphorous to Red phosphorous** Yellow phosphorus is converted into red phosphorous in covered retorts containing a reflux condenser to retain any evolved phosphorous vapors. The vessel is gradually heated and the contents melt and slowly change to red phosphorus. This mass is solidified when approximately 70% has been converted. Heat control is required as reaction is exothermic. **Reaction**	3

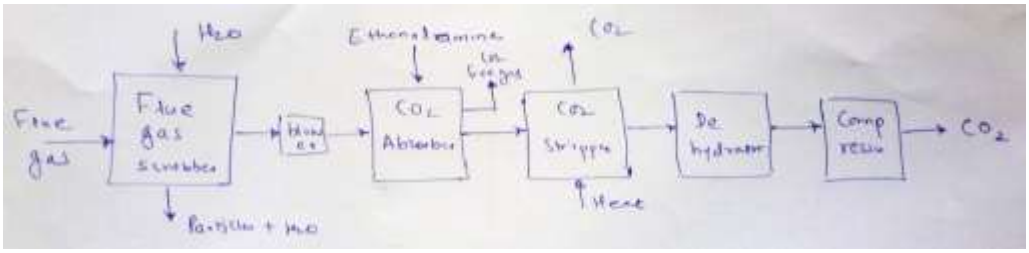
	P_4 (Yellow) + heating = P_4 (Red)	1
c)	**Comparison between dry &wet process** Dry process- 1) Cheaper 2) Accurate control of raw materials is not possible. 3) Raw materials are mixed in dry condition 4) the dry process is used for the mfg. of cement when the raw material is either cement rock or blast furnace slag. Wet process- 1) Costlier 2) Accurate control of raw materials possible. 3) Raw materials are mixed with water. 4) This process is used for any raw materials.	1 mark for each point
d)	**Furnace used in Phosphorous manufacturing** 	4
e)	**Water Gas (continuous process):** Raw materials: Steam, coal, oxygen Reactions: $C + O_2 \longrightarrow CO_2$ $C + H_2O \longrightarrow CO + H_2$	4

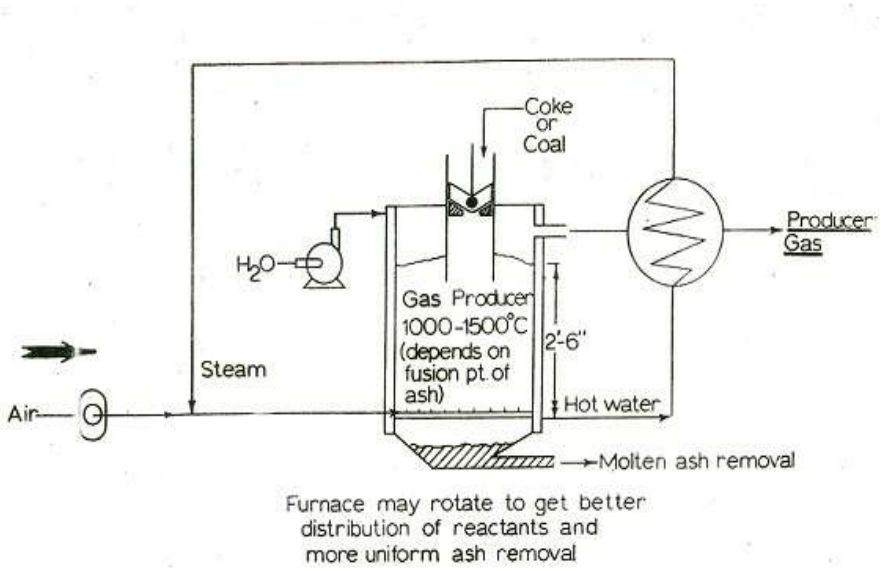
	Process description: This process was invented in 1940 by Germans. This process is based on use of tonnage or low purity grade oxygen made by air separation procedure. The correct ratio of steam, oxygen and coal is added to the reactor to yield a self-sustaining reaction of approximately zero heat release. Subsequent innovations allow for ash content >30% so Indian coal can be used in this process. Or **Water Gas (regenerative process):** The plant is provided with two generators one operates on blow period which heats carbon and the other on a run period where exothermic reactions accur. During the steam run water gas is produced. This is come out through an exit near the top and collected. During the air run warming up process when air is blown in the products of combustion mainly Nitrogen,CO_2,CO are allowed to pass into the atmosphere	4
f)	**Uses of hydrogen (any four)** • For the production of ammonia • For the production of inorganic acids • As a fuel in rocket • As a coolant in generator • For the hydrogenation of vegetable oil • For enhancement of plasma welding It is used as automobile fuels	1 mark each for any four
5	**Attempt any two**	**16**
a)	**Ammonium Nitrate**	

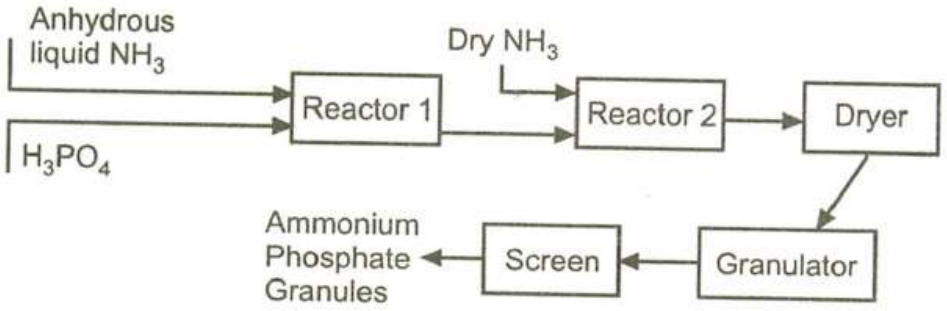
	Process description – In the Stengel process, vapours of ammonia & nitric acid are mixed in a stainless steel reactor. The reaction is exothermic & hence heat is given out. The mixture of steam & molten ammonium nitrate is fed to cyclone type separator. The molten mass is solidified on the water cooled 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.	3
	Reaction $HNO_3 + NH_3 \rightarrow NH_4NO_3$	2
		3
b)	**Acetylene from CaC_2** Raw materials: lime stone, coke, water	2
	Chemical reactions: $CaO + 3C \rightarrow CaC_2 + CO$ $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + CH{\equiv}CH$ $CaCO_3 \rightarrow CaO + CO_2$ $2CO + O_2 \rightarrow 2\ CO_2$ Process Description: Calcium carbide is produced by heating lime and coke in an electric furnace at	3

	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 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.	

		3
c)	**Name of mixed fertilizer:** 1.NPK complex 2.Nitrophsphate 3. Diammonium phosphate 4.Ammonium phosphate sulphate etc (name of any fertilizer which contain at least two component from N,P&K) N.P.K. means Nitrogen, Phosphorus & Potassium Mixed fertilizers are more popular because Mixed fertilizers are capable of supplying all or several elements needed for plant nourishment. All the three major plant nutrients are made available in one and the same material. There is saving of time and labor. The residual effects will not be there. The fertilizer mixtures are usually prepared taking into account the acidic or alkaline nature of the ingredients, and other chemical reactions. Hence, some of the residual	3 2 3

	effects like acidity will not be there. Usually mixed fertilizer are prepared to suit a group of crops and soils	
6	**Attempt any four**	**16**
a)	**Block dihram of CO_2 production (from flue gas)** 	4 Marks can be given for any method
b)	**Plaster of Paris,** quick-setting gypsum plaster consisting of a fine white 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 2
c)	**Biurete** It is the result of condensation of two molecules of urea and is a problematic impurity in urea-based fertilizers. $2\ CO(NH_2)_2 \rightarrow H_2N\text{-}CO\text{-}NH\text{-}CO\text{-}NH_2 + NH_3$ **Uses of Urea** 1. As a fertilizer 2. Cattle feed 3. For production of urea formaldehyde 4. As a flame retreading agent	2 1 mark each for any two uses

d)	**Flow diagram for manufacturing of producer gas** 	4
e)	**Single and triple super phospahte** **Parameter** | **Single Superphospahte** | **Triple Superphosphate** Raw material | Phosphate rock, sulfuric acid | Phosphate rock, phosphoric acid Uses | Fertiliser | Fertiliser Process | It requires 24 hours storgae | It can directly granulated after reaction. Reaction | $[Ca_3(PO_4)_2]_3CaF_2 + 7H_2SO_4 = 3CaH_4(PO_4)_2 7CaSO_4 + 2HF$ | $CaF_2.3Ca_3(PO_4)_2 + 14H_3PO_4 = 10Ca(H_2PO_4)_2 + 2HF$	1 mark each for 4 parameters
f)	**Ammonium Phosphate** Anhydrous and dry ammonia and phosphoric acid are charged into the first	

	reactor. About 80% neutralization is done in the first reactor. Further ammonia is added to second reactor. So conversion to the di-ammonium salt is obtained. The reaction is exothermic and hence due to heat of reaction the excess ammonia vapors are given out this are collected at the top of the tank and recharged. This cuts ammonia losses. The slurry obtained in second reactor is allowed to pass to a rotary adiabatic dryer in which moisture is reduced to less than 1%. The bed of dry particles is recycled by moving them through rotating drum granulator. The particles are screamed and dried further white crystalline solid material is obtained.	2
		2