WINTER-15 EXAMINATION

Model Answer

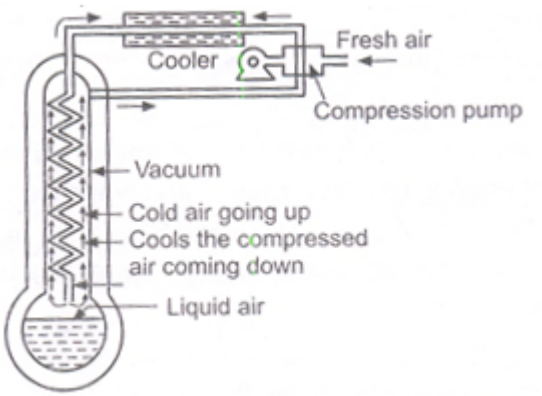
Important Instructions to examiners:

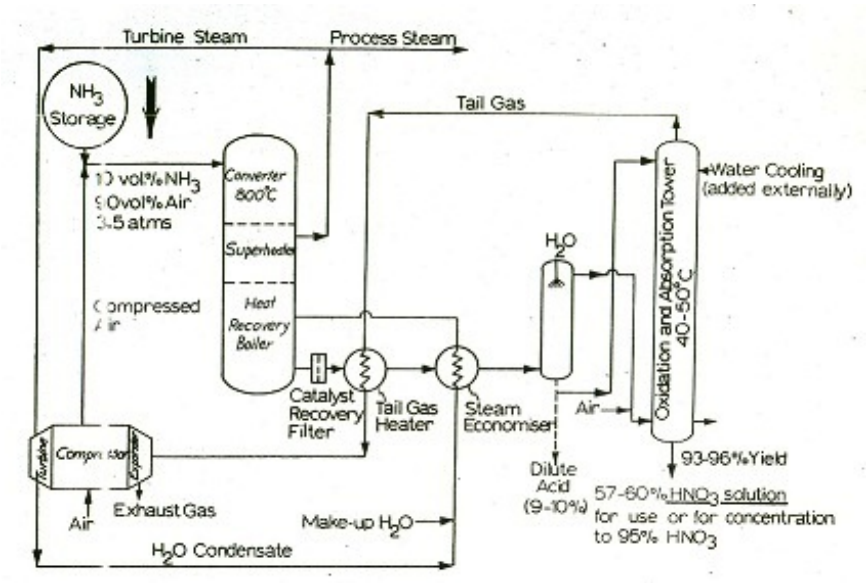
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

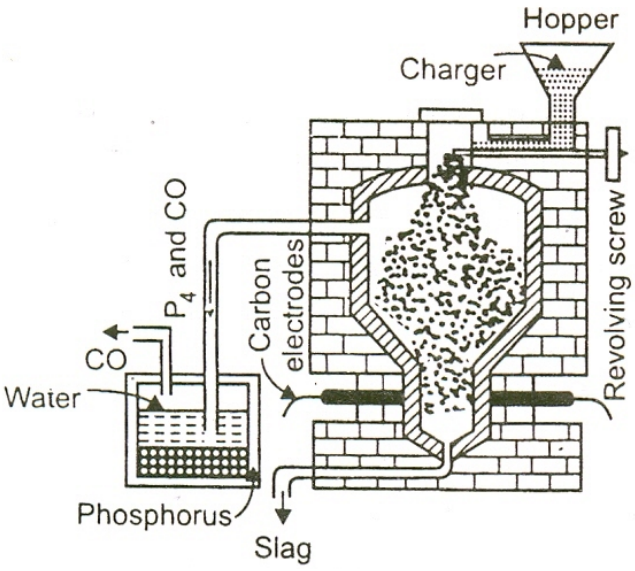
Q No.	Answer	marks	Total marks
	Attempt any six		12
1A-a	**Reactions in sulfuric acid manufacturing** $S + O_2 = SO_2$ $SO_2 + ½ O_2 = SO_3$ $SO_3 + H_2O = H_2SO_4$ In actual process SO_3 is not directly absorbed in water to form sulfuric acid but in conc. sulfuric acid to form oleum.	2	2
1A-b	**Uses of sulfuric acid** a) For manufacturing of Fertilizers b) Oil refining c) Metal processing d) Manufacturing of Rayon e) In Lead acid batteries f) Detergent manufacturing	1mark each for any two	2
1A-c	According to Le chateliers principle the formation of sulphur trioxide will be favored by Low temperature High pressure Increased concentration of sulphur dioxide or oxygen A use of catalyst for attainment of equilibrium for oxidation of SO_2 to SO_3	One mark each for any two	2
1A-d	**Merits of V_2O_5 catalyst over Pt catalyst** • Relatively immune to poison • Low initial investment • Only 5% replacement per year	One mark each for any two	2

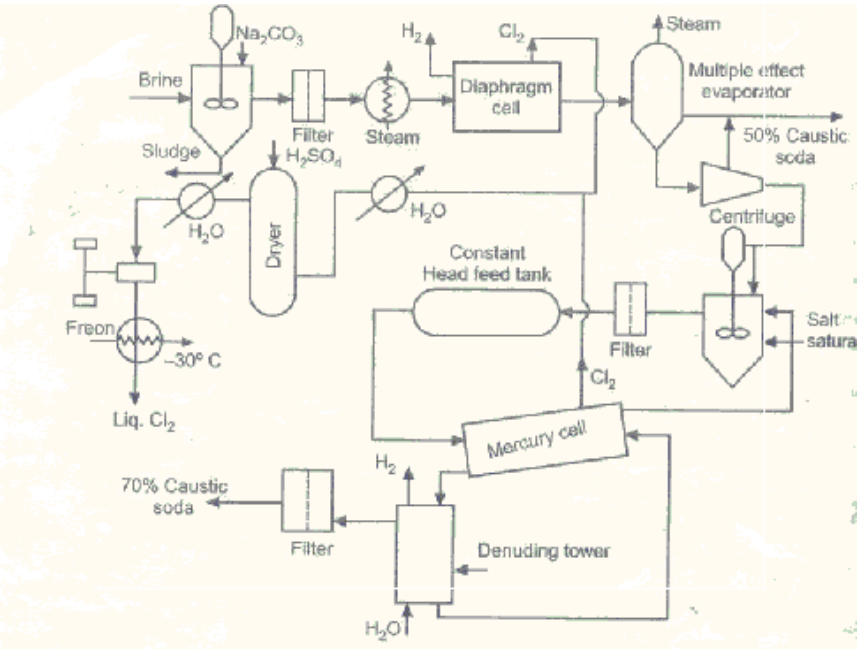
	• Required only 10 kg catalyst pet ton on 100% acid		
1A-e	**Properties of sulfuric acid** • Molecular weight: 98 • Melting point 10.5 ^{o}C • Boiling point 340^{o}C with decomposition • Completely miscible with water with large heat of solution • Formation of oleum with SO_3	One mark each for any two	2
1A-f	Raw material required for ammonia manufacturing 1. Air (source of nitrogen) 2. Synthesis gas (Source of Hydrogen)	One mark each	2
1A-g	**Uses of hydrogen** 1. Hydrogenation of oil 2. Ammonia production 3. Fuel 4. Methanol production 5. Coolant in power generator	One mark each for any two	2
1A-h	**Types of cement** 1) Portland cement 2) Pozzolanic cement 3) Natural cement 4) High alumina cement 5) Super sulphate cement 6) Quick setting cement	Any four (half mark each)	2
1B	**Attempt any two**		8
1B-a	**Properties of chlorine** MW : 35, MP: – 101.5 ^{o}C, BP : -34.4 ^{o}C		

	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** 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** MW : 40, BP : 1390^{o}C, MP : 318 ^{o}C , Very soluble in water with high exothermic heat of reaction. **Uses of Caustic soda** 1. Textile industry 2. Paper and Pulp 3. Alumina 4. Soap and detergent 5. Dyes	1 1 1 1	4
1B-b	**LINDES PROCESS:** 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. During expansion work is not done against external pressure but against internal attraction force between the molecules. Flow diagram:	4	4

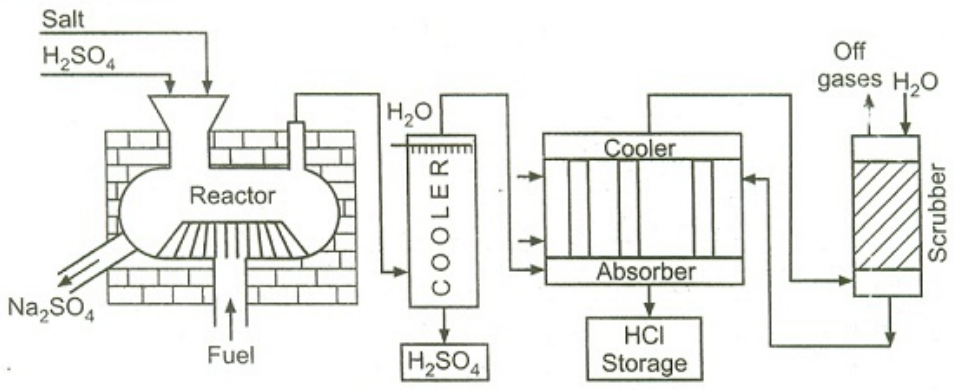
	 Process description: Air free from CO_2 is compressed to about 200 atm pressure, and cooled by passing through a pipe surrounded by cold water. this cooled and compressed air passes through a spiral and escape through a small orifice or nozzle, when it is cooled by the above effect. This cooled air passes upwards surrounding the spiral pipe and cools the down coming air there in. The cooled air is further cooled by expansion and cooling is thus continued till it begins to condense. The up going air is compressed once again and is recirculated.		
1-B-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 obtained is known as clinker removed from the lower end of the kiln then	4	4

	ground with 2% gypsum to obtained Portland cement.		
2	**Attempt any two**		**16**
2-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 different feed	Rection-2 Diagram-3 Process-3	8

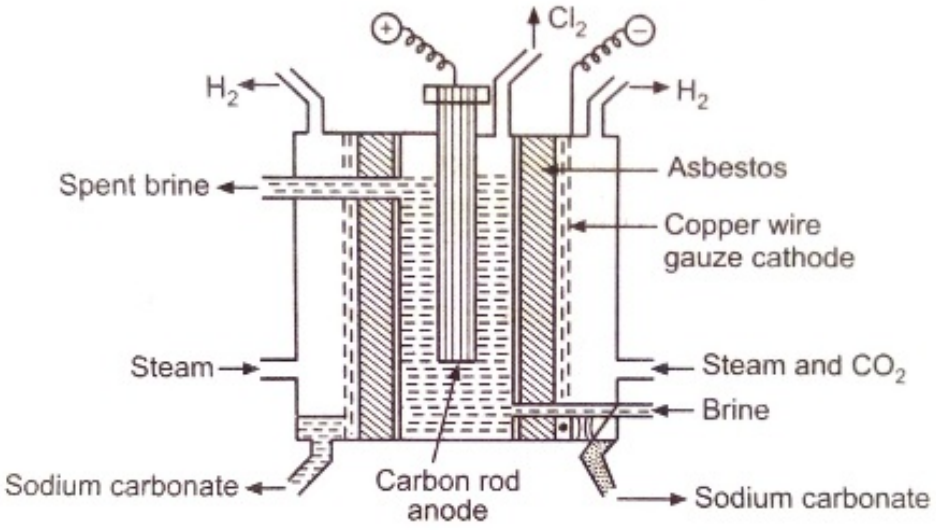
	plates. Air is provided from the bottom to complete oxidation of NO. Water is fed from the top of the tower. Nitric acid (60%) is collected at the bottom. Tail gases from the absorber are used to run gas expander after heating.		
2-b	**Electro thermal process:** A mineral phosphate with sand and coke is charged in the electric furnace. It is heated upto 1400 to 1500 ^{o}C. Initially at 1150^{o}C, SiO_2 displace more volatile P_2O_5 from calcium phosphate. P_2O_5 is then reducing to phosphorous by coke at 1500^{o}C. 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-2 Diagram-3 Process-3	8

2-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°C and collected as liquid chlorine  	4 4	8
3	**Attempt any four**		**16**
3-a	**Difference between wet process and electric furnace process:**	1 mark	4

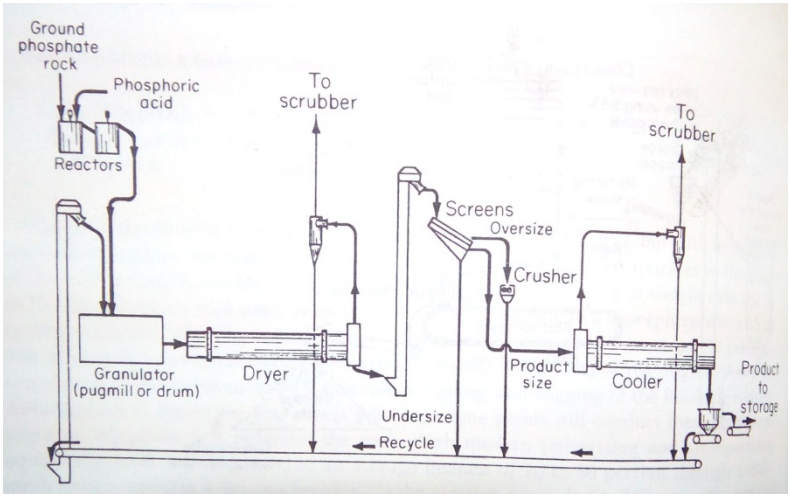
	<table><tr><th>Wet Process</th><th>Electric furnace process</th></tr><tr><td>1. High grade phosphate rock is used</td><td>Low grade phosphate rock is used</td></tr><tr><td>2. Cost of plant is low</td><td>Cost of plant is high</td></tr><tr><td>3. Comparatively low pure acid is obtained</td><td>Highly pure acid can be obtained</td></tr><tr><td>4. This process doesn't get affected by rate of electricity</td><td>This process is economical in those places where electricity is quite cheap</td></tr><tr><td>5. Phosphate rock is finely ground and prepulped in the mixing tank with cooled recycled H3PO4 from the slurry cooler</td><td>Phosphate rock ground and sized. Rock and sand mixed with coke, sintered and introduced into electric furnace</td></tr><tr><td>6. Reaction temperature is comparatively low</td><td>Reaction temperature is high</td></tr></table>	for any 4	
3-b	**Yellow phosphorus is converted to red phosphorus by** 1. Heating yellow phosphorus to 300°C in the absence of air 2. By exposing yellow phosphorus to sunlight. 3. Red phosphorus exists as an amorphous network. Upon further heating, the amorphous red phosphorus crystallizes. 4. Due to heating phosphorus molecules get rearranged in the solid crystal lattice.	4	4
3-c	**Raw material and Reactions in single superphosphate** Raw materials: Phosphate rock, Sulphuric acid Chemical reactions: $Ca_3(PO_4)_2 + 2\ H_2SO_4 + 4\ H_2O \longrightarrow CaH_4(PO_4)_2 + 2(CaSO_4.2H_2O)$ Monocalcium phosphate — Gypsum $CaF_2 + H_2SO_4 + 2H_2O \longrightarrow CaSO_4.2H_2O + 2\ HF\uparrow$ $4HF + SiO_2 \longrightarrow SiF_4 + 2\ H_2O$ $3\ SiF_4 + 2\ H_2O \longrightarrow SiO_2 + 2H_2SiF_6$	1 3	4

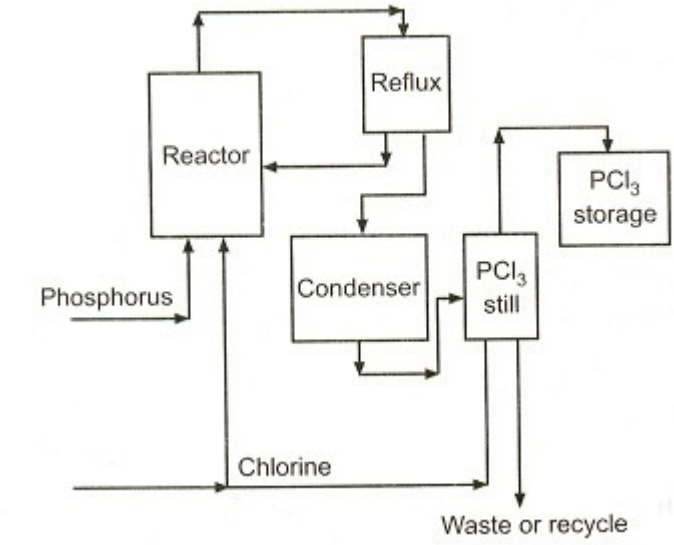
3-d	**Salt and Sulphuric acid method:** $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$ $NaHSO_4 + NaCl \longrightarrow Na_2SO_4 + HCl$ Both reactions involve the displacement of volatile acid from salt. The equilibrium can be displaced in desired direction by choice of condition i.e. promoting volatilization of HCl The high temperature process is superior to vacuum for this purpose. To promote reaction rate it is desirable to have temperature sufficiently high to keep at least one of the reacting component in liquid condition. There is no difficulty in first stage of decomposition but second stage required temperature of about 400 ˚C to liquefy $NaHSO_4$. The higher limit to temperature is the attack of corrosive relative mass on furnace. The product and unconverted H_2SO_4 is send to further processing in which there is recovery of H_2SO_4 by cooling and HCL is recovered as main product from absorber.  	1 2 1	4
3-e	**Electrolytic Process:**		4

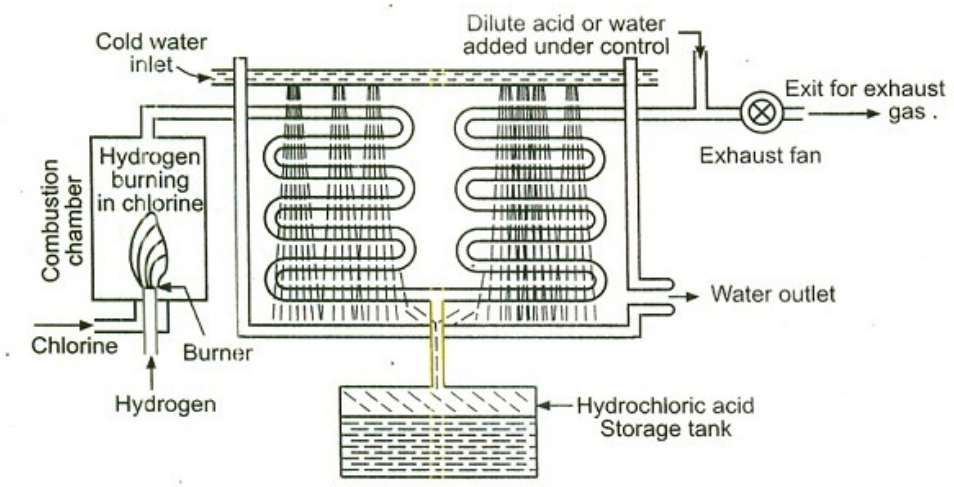
	In this process carbon dioxide is passed in the solution of sodium hydroxide obtained by the electrolysis of aqueous solution of sodium chloride. $2NaOH + CO_2 \longrightarrow Na_2CO_2 + H_2O$ The electrolysis of sodium chloride is carried in an iron box lined with bricks. A carbon rod is used as the 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.	2 2	

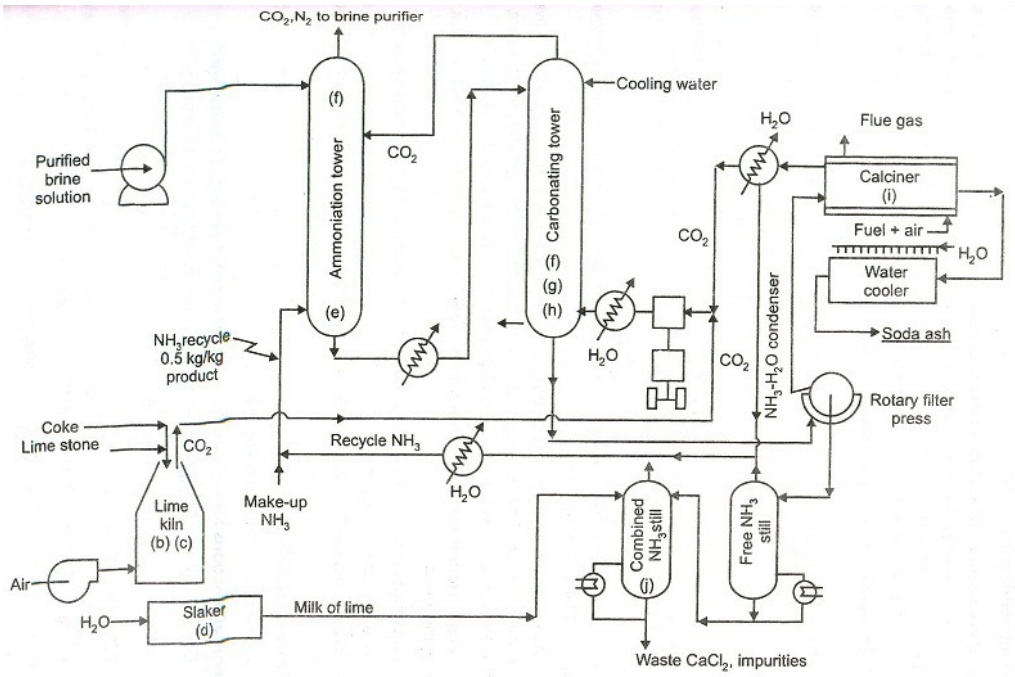
			
3-f	**Sodium Carbonate:** Raw materials: Salt(brine), coal, limestone Chemical Reactions: Main reaction is $CaCO_3(s) + 2NaCl\ (aq) = Na_2CO_3 + CaCl_2$	1 3	4

	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) $2NH_4Cl_{(aq)} + Ca(OH)_{2\,(s)} \longrightarrow 2\,NH_{3\,(g)} + CaCl_{2\,(aq)} + 2\,H_2O_{(l)}$		
4	**Attempt any four**		**16**
4-a	**Triple superphosphate** This material is much more concentrated fertilizer then ordinary superphosphate it contains from 45 to 46% of available P_2O_5 of nearly three times the amount in the regular superphosphate. Chemical reaction:	2	4

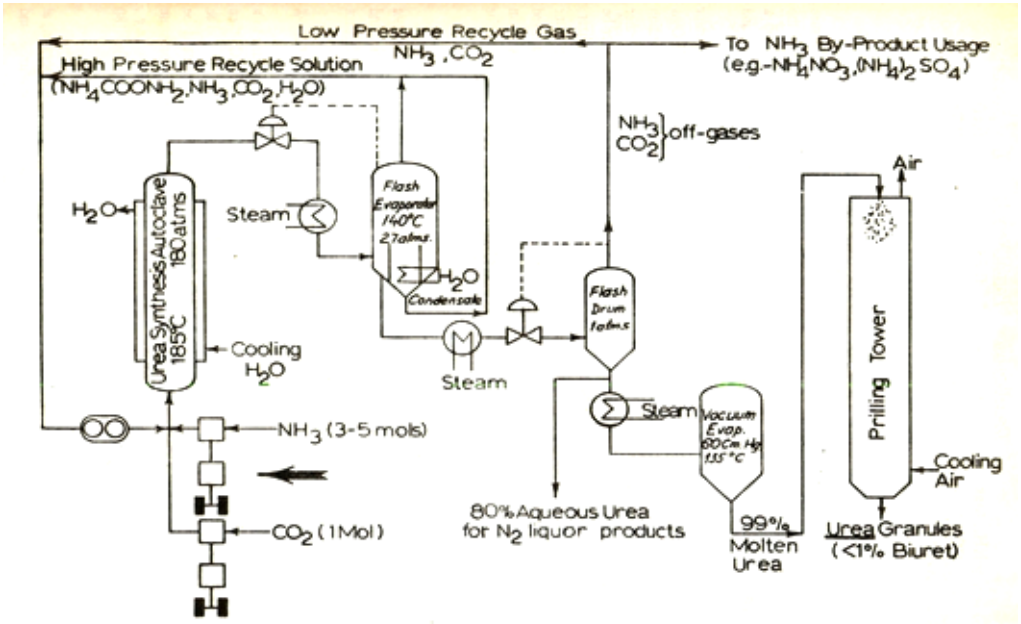
	$CaF_2.3Ca_3(PO_4)_2 + 14H_3PO_4 \longrightarrow 10Ca(H_2PO_4)_2 + 2HF$ It is made by action of phosphoric acid on phosphate rock. The pulverized phosphate rock is mixed with phosphoric acid into a two stage reactor. The resultant slurry is sprayed into the granulator The product from the granulator 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.  	2	
4-b	**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	2	4

	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. **Phosphorus pentachloride** is conveniently prepared by passing excess of dry chlorine over liquid phosphorus trichloride in a tank cooled by a freezing mixture. PCl_3 is added drop by drop into it. The unused chlorine is removed by another tube and recycled again. $PCl_3 + Cl_2 \longrightarrow PCl_5$  	2	
4-c	**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. $H_2 + Cl_2 \longrightarrow 2\ HCl$		4

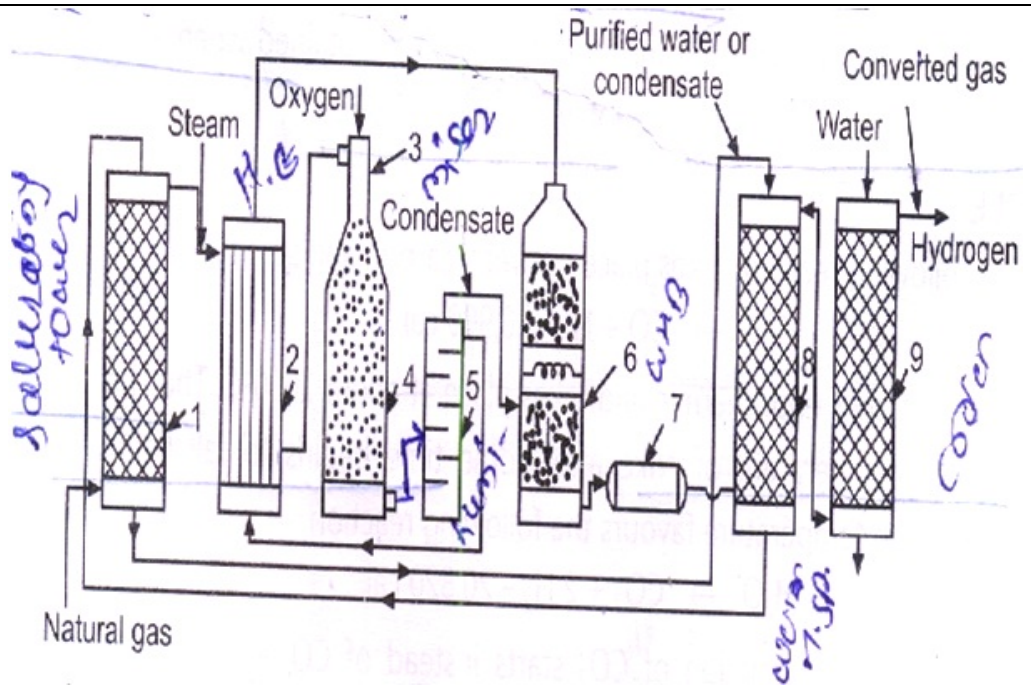
	Dry hydrogen is made to burn in acid resisting burner fitted in a combustion chamber lined with silica bricks. Dry chlorine is passed into the combustion chamber when hydrogen burns in an atmosphere of chlorine to give HCl The gas is passed through a cooler cooled by water spray and then through absorber 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-d	**PFD for solvays soda ash process**		4

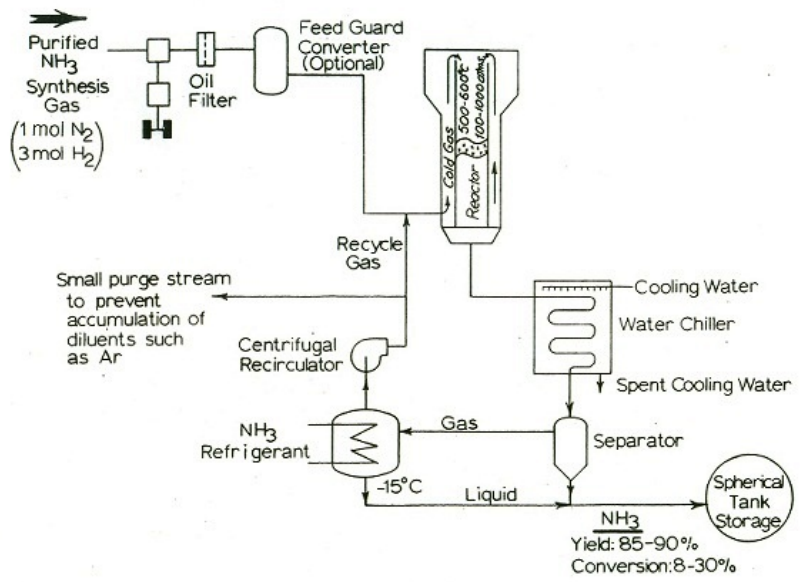
		4	
4-e	**Water Gas (continuous process):** Raw materials: Steam, coal, oxygen Reactions: $C + O_2 \longrightarrow CO_2$ $C + H_2O \longrightarrow CO + H_2$ Process description: This process was invented in 1940 by Germans. This process is based on use of tonnage or low purity grade oxygen made by air 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	2 2	4

	in this process		
4-f	**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 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.	1 3	4
5	**Attempt any two**		**16**

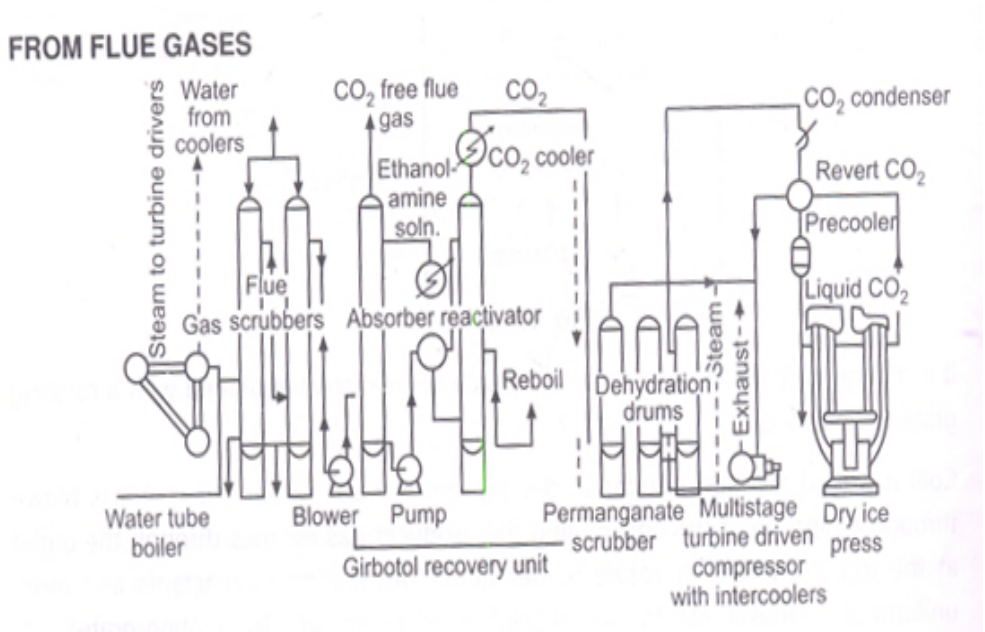
5-a	**Urea by Montecatini Process:** Chemical reaction: i) CO_2(carbon dioxide) + $2NH_3$ (ammonia) → $NH_4.COO.NH_2$ (ammonium carbamate) ii) $NH_4.COO.NH_2$ (ammonium carbamate) → $NH_2.CO.NH_2$ (urea) + H_2O iii) Undesirable side reaction : $NH_2.CO.NH_2$ (urea) → $NH_2.CO.NH.CO.NH_2$ (biuret) + NH_3 Flow diagram :  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.	Rection-1 Diagram-4 Process-3	8

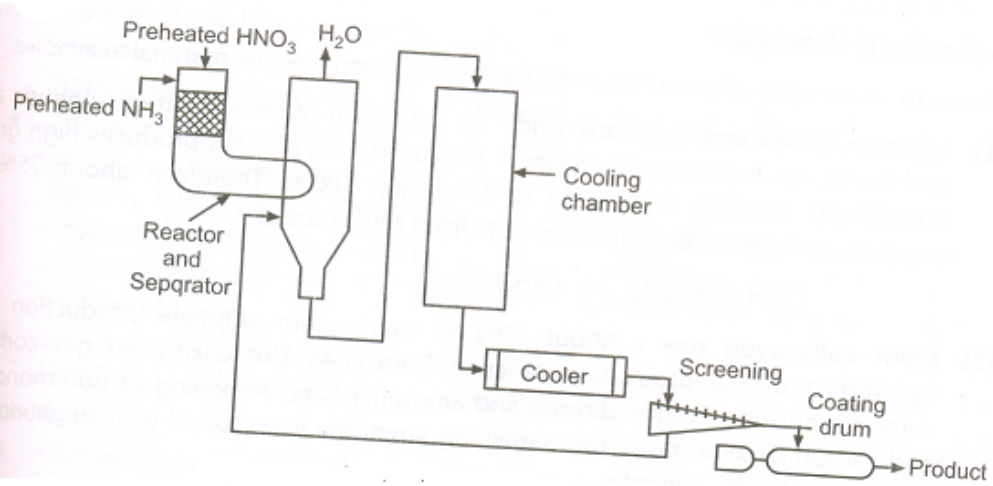
	This liquid effluent is let down to 27 atms and feed to a special flash evaporator containing gas liquid separator and condenser. unreacted NH_3, CO_2 and water as a solution are removed and recycled. An aqueous solution of carbamate urea is passed to the atmospheric flash drum where further decomposition 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.		
5-b	**Production of hydrogen** Hydrogen from natural gas: Natural gas mainly methane is converted into hydrogen by mixing it with steam and passing the mixture over a catalyst nickel with alumina at 800-900^oC . The natural gas is passes through a saturating tower saturated with water vap. At the exit steam is added and the steam gas mixture directed to the heat exchanger at 500-600^oC .The gas mixture goes to mixture chamber where O_2 is introduced .This is entered at 450^0C to methane convertor , After adding the catalyst at 800^o C passed to humidifier where water vap. is added to reduce the temp. upto 750^o C .The gases passes through heat exchanger which gives a heat to the gas going to the mixture chamber converted at 400^o c and entered at carbon monoxide convertor. The gases are send to waste heat boiler, water tower spray and cooler for removal of CO_2. $CH_4 + H_2O \rightleftharpoons CO + 3\ H_2$	Rection-1 Diagram-3 Process-4	8

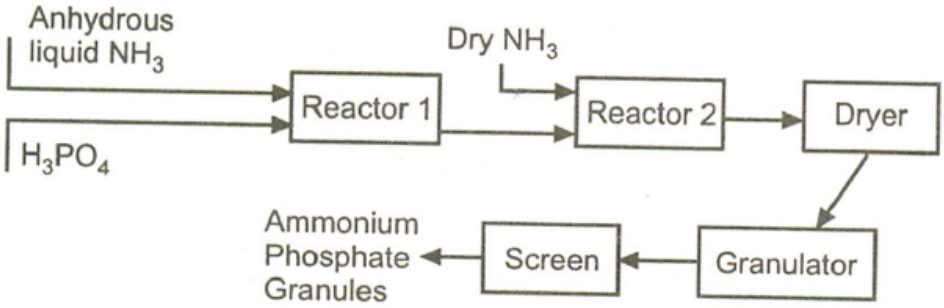
			
5-c	**Ammonia** Raw Material: Synthesis gas, Air Reaction : $N_2+3H_2 = 2NH_3$ Process Ammonia synthesis gas is compressed to the operating pressure. It is send through a filter to remove compression oil and additionally through a high temperature guard converter to convert carbon monoxide, carbon dioxide to methane and remove traces of water vap, hydrogen sulfide. This is done by catalyst and suitable getter material. The relatively cool gas is added along the outside of converter tube walls to	1 4	8

	provide cooling so that carbon steel can be used for the thick wall pressure vessel and internal tubes. The preheated gas flows next through the inside of the tubes which contain promoted porous iron catalyst at 550°C. The ammonia product with an 8-30% conversion depending on process condition is removed by condensation, first with water cooling and then ammonia refrigeration. The unconverted N_2-H_2 mixture is re circulated to allow 85-90% yield.  	3	
6	**Attempt any four**		**16**
6-a	Advantages of solvay process 1) Higher Yield 2) Require less power 3) Low purity brine can be used 4)Less corrosion problem 5)No co products to dispose 6)Do not require ammonia plant	1 mark each for any four	4

6-b	**Cement by wet process:** In the wet process the limestone brought from the quarries are crushed to smaller fragments. Then it is taken to a ball or tube mill where it is mixed with clay or shale as the case may be and ground to fine consistency of slurry with the addition of water. The slurry is a liquid of creamy consistency with water content of about 35-50 per cent, where in particles are crushed to fineness of Indian standard sieve of number 9, are held in suspension. The slurry is pumped to slurry tanks or basins where it is kept in an agitated condition by means of rotating arms with chains or blowing compressed air from the bottom to prevent setting of limestone's and clay particles. The corrected slurry is sprayed on to the upper end of rotary kiln against hot heavy hanging chains. The rotary kiln is an important component of a cement factory. It is a thick steel cylinder of diameter of anything from 3 meters to 8 meters lined with refractory materials, mounted on a roller bearing and capable of rotating about its own axis at specified speed. The length of the rotary surface of flexible chain loses moisture and becomes flakes. The rotation to the rotary Kline causes the flakes to move from the upper end toward the lower end of the kiln subjecting itself to higher and higher temperatures. The kiln is fired from the lower end. The fuel is either powered coal oil or natural gas. By the time the material rolls down to the lower end of the rotary kiln, the dry material undergoes a series of chemical reactions until finally, in the hottest part of the kiln, Where the temperature is in the order of 1500 Celsius about 20-30 per cent of the materials get fused. Lime, silica and alumina get recombined. The fused mass turns into nodular form of size 3mm to 20mm known as "clinker". The clinker drops into a rotary cooler where it is cooled under controlled conditions. The clinker is cooled is then grind in ball mill with the addition of 3-5 per cent of gypsum in order to prevent flash-setting of the cement.	4	4

6-c	**Manufacturing of CO_2 by flue gas: Process description**: Fflue gases result from burning carbonaceous material are cooled, purified and washed by passing through two water scrubbers contain Na_2Co_3. ($Na_2Co_3 + CO_2 + H_2O \rightarrow 2NaHCO_3$) The reaction to left is formed by heating $NaHCO_3$.CO_2 is absorbed in absorber by counter current selective absorption. in aq.solution of ethanolamine CO_2 and steam passed through reactivator and then through CO_2 cooler to condensed steam which returns to the tower as reflux.CO_2 passes through permagnet scrubber where traces of H_2S amines are removed it is dried by passing it through dehydration drums. finely CO_2 is condensed cooled in precooler and sent to liquid CO_2 receiver for liquefaction.  	2 2	4
6-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	2	4

	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	
6-e	**Phosphoric acid by wet process:** Phophate rock is ground to 65%-200 mesh and fed to a chute where a recycle stream of weak phosphoric acid washes it into a reaction tank. Strong sulfuric acid is metered with automatic control which keeps the acid and rock feed ratio at the desired setting. A single reactor can be designed by proper baffling and residence time capacitance to permit 98% conversion in 4-6 hrs. Heat of reaction is controlled by pulling cooling air across. The gypsum phosphoric acid slurry goes to travelling pan vacuum filter where the 40% acid is removed and cake washed with water. Filtrate from latter is returned to the reactor. The gypsum is free filtering and cake thickness of about two inches can be readily obtained. The gypsum can either be dried for use in plaster, paints and cements or reacted with ammonium carbonate to produce fertilizer. The dilute acid is concentrated in a single effect evaporator to any grade.	4	4

6-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	4