WINTER–18 EXAMINATION

Model Answer

Subject Name: Technology of Inorganic Chemicals **Subject Code:** 22314

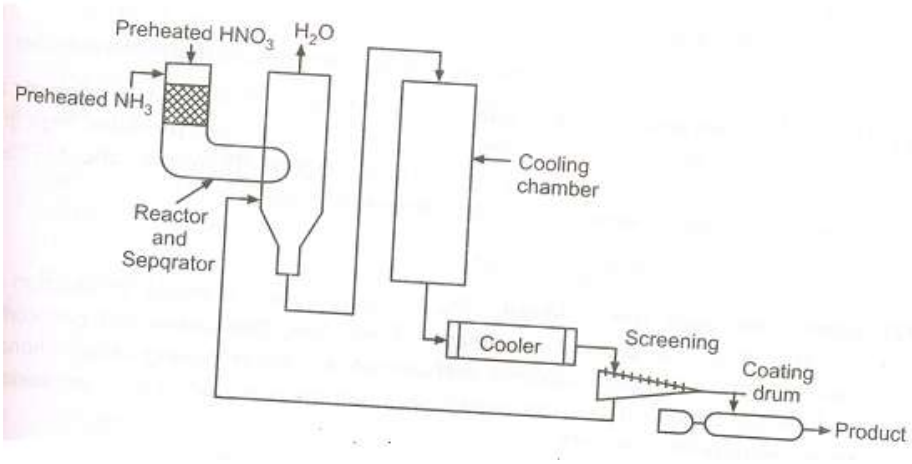
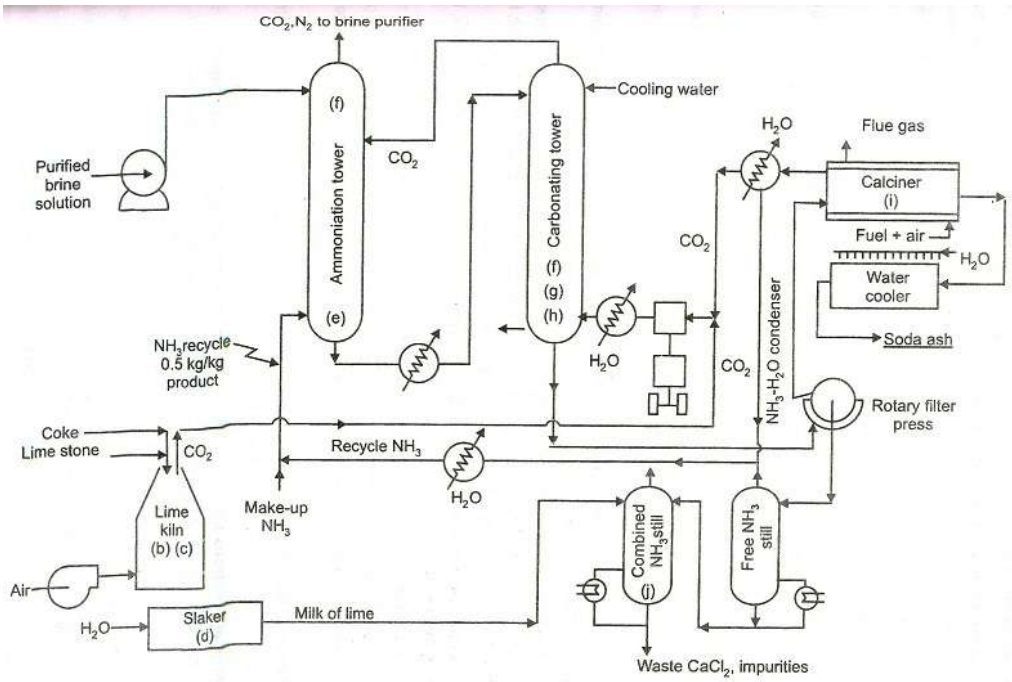
Important Instructions to examiners:

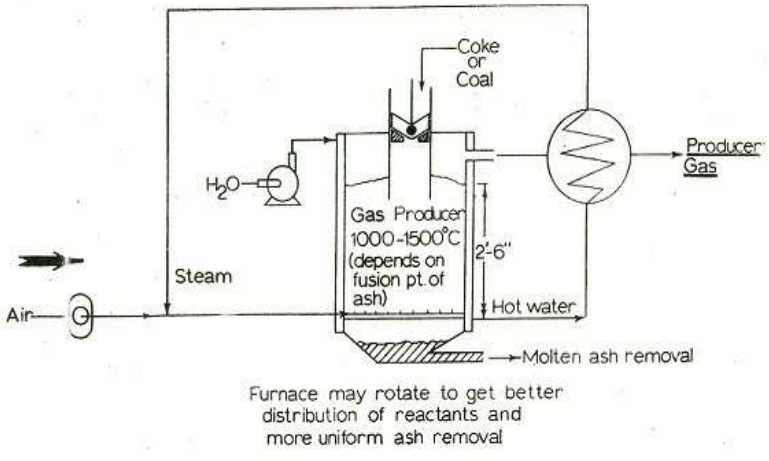
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

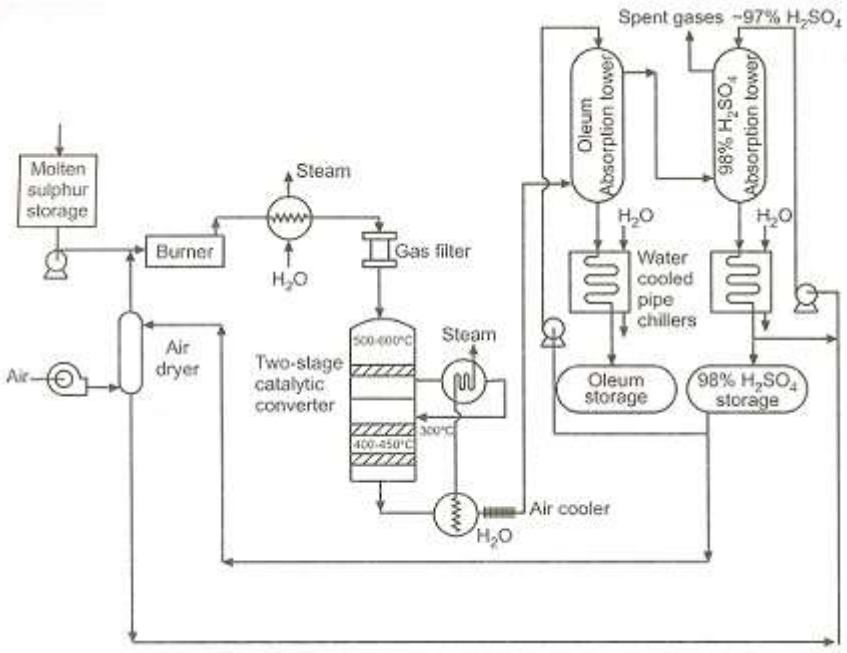
Q. No.	Sub Q. N.	Answer	Marking Scheme
1		**Attempt any five of the Following**	10
	a)	**Claudes Principle** When a cooled compressed gas is allowed to some external work e.g. pushing the piston of gas engine, it falls in temperature. **Lindes Principle** The principle underlying is joule – Thomson effect 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.	1 1
	b)	**Calcination in cement process** Calcination reactions usually take place at or above the thermal decomposition temperature (for decomposition and volatilization reactions) or the transition temperature (for phase transitions). In cement process lime stone calcination takes place with following reaction $CaCO_3 \rightarrow CaO + CO_2(g)$ CaO is important constituent of cement.	2

	c)	**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
	d)	**Yellow Phosphorous** Phosphorus is a chemical element with symbol P and atomic number 15 with self-imagination property when exposed to air. **Red Phosphorous** Phosphorus is a chemical element with symbol P and atomic number 15	1 1
	e)	**Industrial applications of Ammonium nitrate (two)** **Used as or in** 1. Fertilizer 2. Explosive 3. Instant cold pack 4. Guanidine nitrate 5. Alternative to 5-aminotetrazole (used in airbags)	2
	f)	**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
	g)	**Properties of urea(two)** M.P 133 ^{o}C MW 60 Soluble in water	1

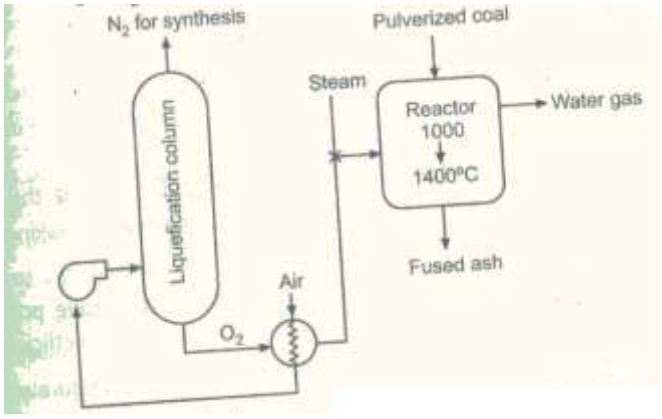
		Non toxic Non flammable **Raw materials:** 1. Carbon dioxide 2. Ammonia	1
2		**Attempt any three of the following**	**12**
	a)	**Manufacturing process of Nitric Acid** Ammonia and air are compressed and send to the catalytic converter. Ammonia is oxidized and converted into nitric oxide. Large heat is evolved which is 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 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. *Reaction* $4NH_3+5O_2 = 4NO +6H_2O$ $2NO+O_2 = 2NO_2$ $3NO_2+H_2O=2HNO_3+NO$	3 1
	b)	**PFD of Ammonium Nitrate**	4

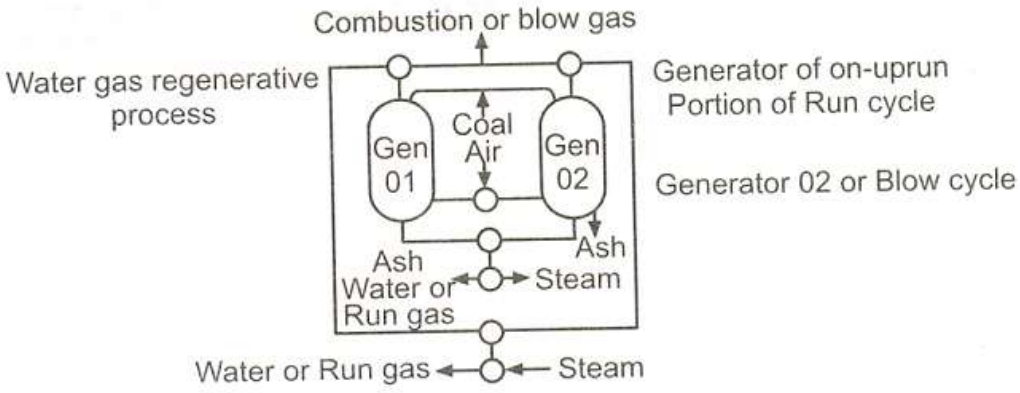
			
	c)	**Single and triple super phospahte w.r.t. raw material and uses** **Parameter** / **Single Superphospahte** / **Triple Superphosphate** Raw material / Phosphate rock, sulfuric acid / Phosphate rock, phosphoric acid Uses / Fertiliser / Fertiliser	2 for raw material based + 2 for use based
	d)	**PFD for manufacturing of Soda Ash** 	4
3		**Attempt any three of the following**	**12**

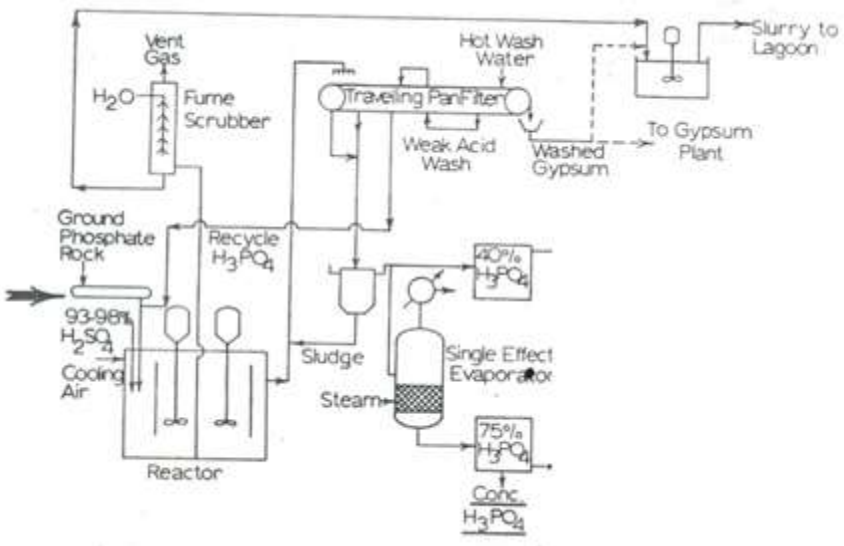
	a)	**Types of cement** 1) Portland cement 2) Pozzolanic cement 3) Natural cement 4) High alumina cement 5) Super sulphate cement 6) Quick setting cement	1 mark each for any four
	b)	**Producer gas**, It is a mixture of flammable gases (principally carbon monoxide and hydrogen) and nonflammable gases (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 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.  Furnace may rotate to get better distribution of reactants and more uniform ash removal	2 2
	c)	**PFD of Sulfuric acid production**	4

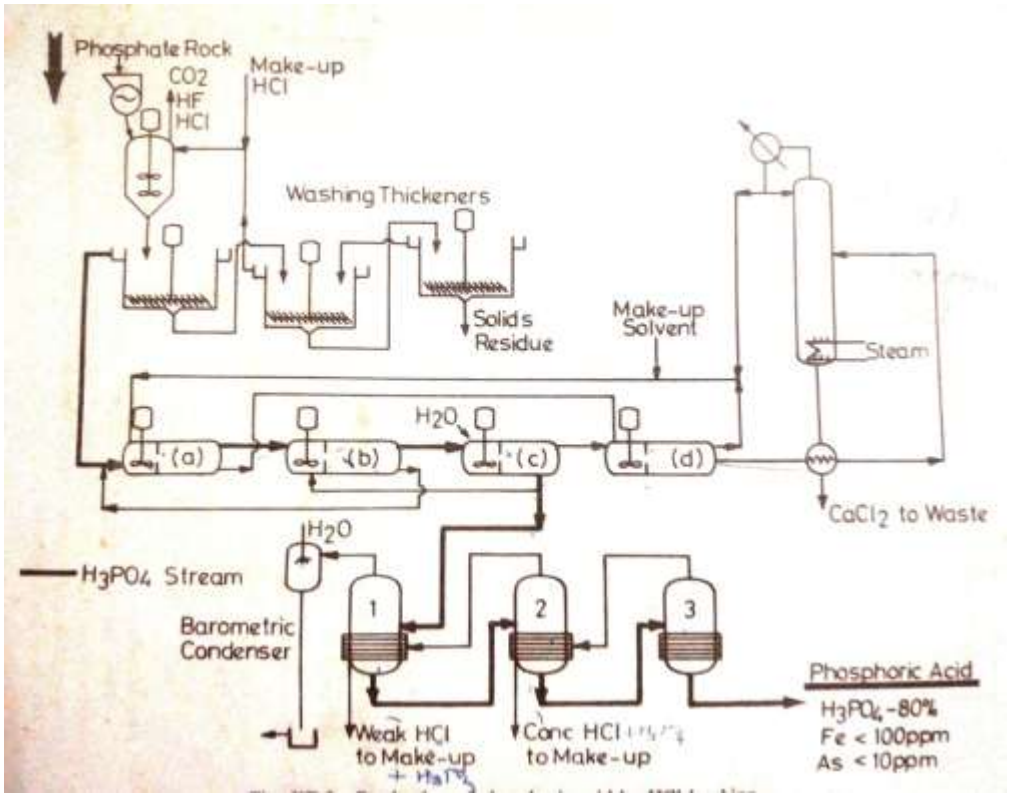
			
	d)	**Industrial applications of Urea (any two)** 1. As a fertilizer 2. Cattle feed 3. For production of urea formaldehyde 4. As a flame retreading agent **Industrial applications of ammonia (any two)** 1. For production of urea 2. For production of nitric acid 3. For production of ammonium nitrate 4. For production of ammonium phosphate 5. As refrigerant	1 mark each for any two 1 mark each for any two
4		**Attempt any three of the following**	**12**
	a)	**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	4

		solidified when approximately 70% has been converted. Heat control is required as reaction is exothermic. **Reaction** P_4 (Yellow) + heating = P_4 (Red)	
	b)	**Potassium Fertilizer** The main potassium fertilizers are potassium nitrate, potassium sulphate. **Manufacturing of potassium nitrate:** KCl + HNO3 → KNO3 +HCl KCl and chilled 60-70% HNO3 are fed into reactor at 5-10^{0}C. Recycled brine and solvent are added to the reactor. In the presence of the solvent, the reaction goes on completion and potassium nitrate crystallizes out. Solid product separated out in decanter and dried in dryer. It can be sold in powdered and prilled form. Unreacted nitric acid and hydrochloric acid recycled and separated from the process. Or **Manufacturing of potassium sulphate** KCl + H2SO4 → KHSO4 +HCl KHSO4 + KCl → K2SO4 +HCl The potassium chloride reacts during slow mixing in the heated furnace with sulphuric acid producing gaseous HCl and K2SO4. The furnace is heated by natural gas. The product is cooled in a cooling drum. Lump material from cooler is crushed and finished or can be compacted and granulated with KCl.	4
	c)	**Types of refractories** The refractory material are commonly classified in three categories **Acid Refractories** These are acidic in nature. Examples of acidic Refractories are silica and fire clay Refractories. Silica bricks are very hard and used for high temperature resistance applications. **Basic Refractories**	4

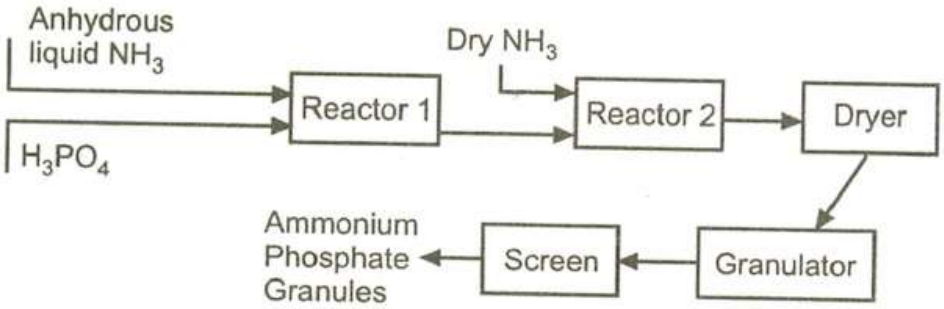
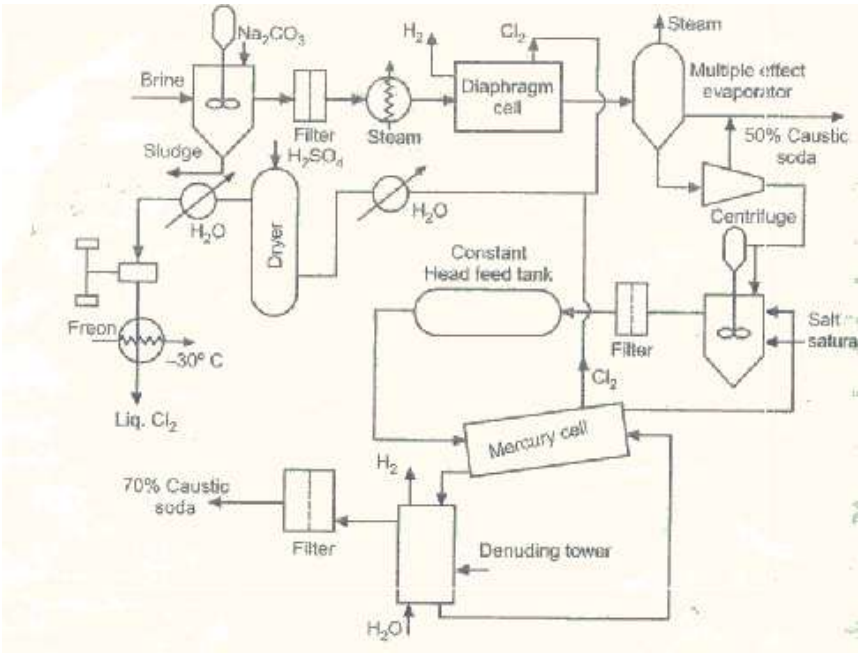
		It consists of basic materials therefore they are not attacked by basic materials like bauxite, magnesite, dolomite, lime etc. These are alumina, Magnesia and dolomite **Neutral Refractories** These are not neutral in chemically. They consists of partly acidic and partly basic materials with the result that they resist both acidic and basic actions. These are chromite, graphite, silicon carbide etc refractories.	
	d)	**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.  **Or** **Water Gas (regenerative process):**	2 marks description + 2 mark diagram

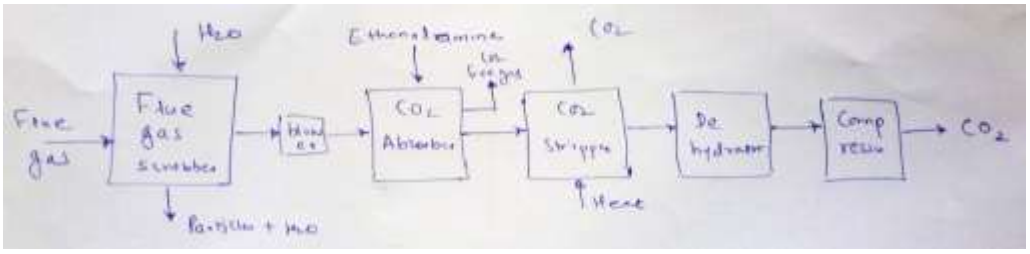
		The plant is provided with two generators one operates on blow period which heats carbon and the other on a run period where exothermic reactions occur. During the steam run water gas is produced. This is come out through an exit near the top and collected. During the air run warming up process when air is blown in the products of combustion mainly Nitrogen,CO_2,CO are allowed to pass into the atmosphere  	
	e)	**Importance of mixed fertilizer** The mixed fertilizers typically consist of two or more elements of nitrogen, phosphorous and potassium (NPK) for promoting the nutritional growth of plants and yield high growth. These are obtained by mixing manually or mechanically. These are recommended by agricultural scientist to enhance the output of plants by giving specific and exclusive blend of plant nutrients. They are tailor made as per the soil and are crop specific. Mixed fertilizers are important because: 1) They provide all nutrient at once and readily available in low cost as compared to single nutrient 2) Available in granular form and easy to apply to soil 3) Mixed fertilizers acidity can be controlled by using specific neutralizers 4) Mixed fertilizers provide the micro nutrients helps to facilitates uniform soil application of plant nutrients Use of mixed fertilizers results in reduction of labor cost as it can easily apply	4

5		Attempt any two of the following	12
	a)	**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. **OR** **2. HCL leaching**	Reaction 1 mark + process 2 marks + PFD 3 marks

		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.  	
	b)	**Raw Material for Ammonium Sulphate** Ammonia + Sulfuric acid Or Coal + carbon monoxide +carbon dioxide + ammonia Or Ammonia + carbon dioxide + gypsum	2 marks for any one

		Chemical reaction for Ammonium sulphate $2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ Or $2NH_3 + CO_2 + H_2O \rightarrow (NH_4)_2CO_3$ $(NH_4)2CO_3 + CaSO_4.2H_2O \rightarrow (NH_4)_2SO_4 + CaCO_3 + 2H_2O$ **Industrial application** Used as or in Fertilizer an additive water treatment and /or cleaning additive	2 marks for any one 1 mark each for any two applications
	c)	**Di 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. **Reaction** $NH_3 + H_3PO_4 \rightarrow NH_4H_2PO_4$ $NH_3 + NH_4H_2PO \rightarrow (NH_4)_2HPO_4$	3 1

			2
6		**Attempt any two of the following**	**12**
	a)	**Manufacturing Process of caustic soda :**  **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	3 3

		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.	
	b)	**Concept of absorption for manufacturing of CO_2 by flue gas** Absorption is unit operation used to separate gas from gas mixture. An absorbent is used in which gas in absorbed. Combustion gases are mainly consists of carbon dioxide. To get pure carbon dioxide combustion gases must be cleaned and CO2 should be separated. These two important steps are carried out by absorption. Detailed process is given below. Flue 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 2
	c)	**Uses of hydrochloric acid (any two)** **Used in or as** a) Pickling of steel b) Regeneration of Ion exchange c) Production of inorganic compounds d) Oil production	1 mark each for any two uses (2 x 3 = 6)

		e) Leather processing **Uses of sulfuric acid (any two)** **Used in or as** a) Oil production b) Fertilizer Production c) Rayon d) Detergent e) Dyestuff f) Pharmaceuticals **Uses of nitric acid (any two)** **Used in or as** a) For manufacturing of ammonium nitrate b) For nitration reaction c) Rocket propellant d) Cleaning agent	