



SUMMER-15 EXAMINATION
Model Answer

Subject code :(17314)

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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.



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Q No.	Answer	Marks	Total marks
1. A a)	Factors affecting the rate of a chemical reaction : 1. temperature, 2. pressure and 3. composition 4. rate of heat transfer 5. Catalyst 6. Nature of reactants 7. Surface area available. 8. Intensity of light if reaction is light sensitive.	½ mark each for any four	2
b)	SO ₃ is dissolved in H ₂ SO ₄ to form or fuming H ₂ SO ₄ . 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 ₂ SO ₄ . These particles do not easily condense down.	2	2
c)	Fuming sulfuric acid is an important intermediate in the manufacture of sulfuric acid due to its high enthalpy of hydration. When SO ₃ is added to water, rather than simply dissolving, it tends to form a fine mist of sulfuric acid, which is difficult to manage. However, SO ₃ added to concentrated sulfuric acid readily dissolves, forming oleum which can then be diluted with water to produce additional concentrated sulfuric acid.	2	2
d)	V₂O₅ catalyst It is preferred now a days due to <ul style="list-style-type: none">• Relatively immune to poison• Low initial investment• Only 5% replacement per year• Required only 10 kg catalyst per ton on 100% acid	One mark each for any two	2
e)	Importance of DCDA process	2	2



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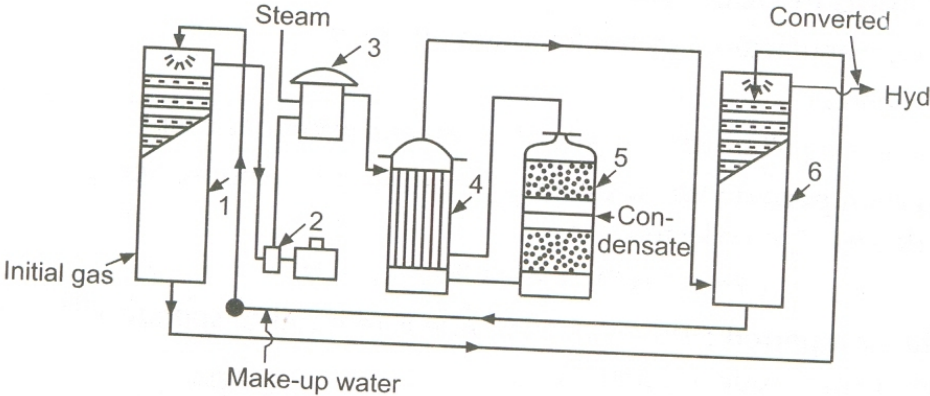
	In this process the product gases (SO ₂) and (SO ₃) are passed through absorption towers twice to achieve further absorption and conversion of SO ₂ to SO ₃ and production of higher grade sulfuric acid.		
f)	Le Chatelier's Principle states: when a change is introduced to a system in equilibrium, the equilibrium shifts in the direction that relieves the change.	2	2
g)	Calcination : To heat a substance to a high temperature but below the melting or fusing point, causing loss of moisture, reduction or oxidation, and the decomposition of carbonates and other compounds.	2	2
h)	Hardening of cement: Hardening is a process of crystallization. Crystals form (after a certain length of time which is known as the initial set time) and interlock with each other. Concrete is completely fluid before the cement sets, and then progressively hardens. The cement and water mixture that has crystallized in this way encloses the aggregate particles and produces a dense material.	2	2
1 B) a)	HCl: Salt and sulfuric acid is reacted to produce hydrochloric acid by following endothermic reaction $\text{NaCl} + \text{H}_2\text{SO}_4 = \text{NaHSO}_4 + \text{HCl}$ $\text{NaHSO}_4 + \text{NaCl} = \text{Na}_2\text{SO}_4 + \text{HCl}$ First reaction takes place with ease but second reaction will require 400 °C.	4	4



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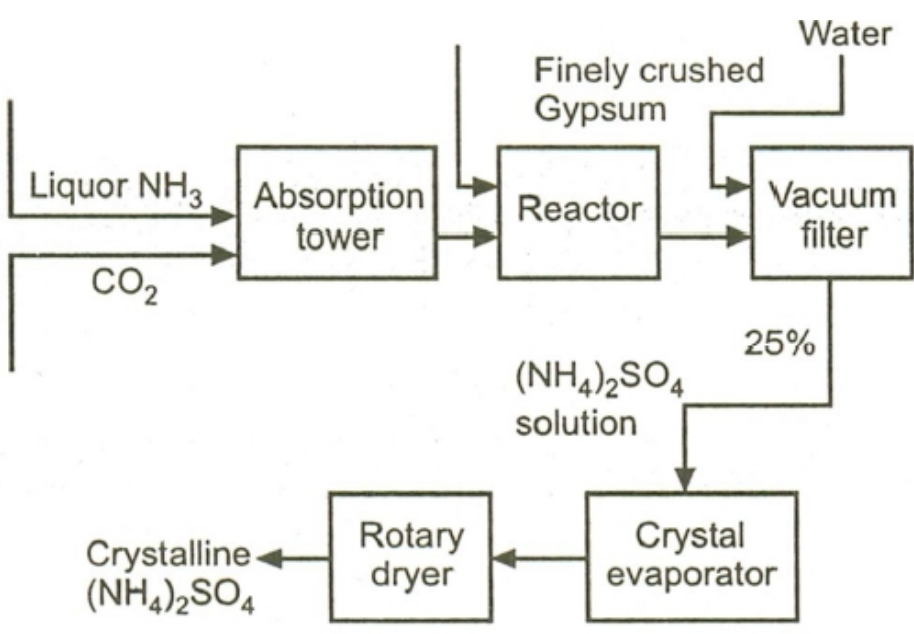
<p>b)</p>	<p>Production of hydrogen from water gas</p>  <p>1-Saturating tower, 2-Blower, 3-Mixer,4-heat exchanger, 5-converter, 6-packed tower.</p>	<p>4</p>	<p>4</p>
<p>c)</p>	<p>Raw material used for cement</p> <p>As a source of calcium</p> <ul style="list-style-type: none">• Lime stone• Calcite• Aragonite• Shale <p>As source of silicon</p> <ul style="list-style-type: none">• Marl• Clay• Sand• Husk• Slag <p>As a source of aluminum</p> <ul style="list-style-type: none">• Fly ash	<p>4</p>	<p>4</p>



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	<ul style="list-style-type: none">• Shale <p>As a source of iron</p> <ul style="list-style-type: none">• Clay• Blast furnace slag		
Q 2 a)	<p>Ammonium sulfate</p>  <p>The flowchart illustrates the production of ammonium sulfate. It starts with an Absorption tower where CO_2 and NH_3 (from NH_4OH) are absorbed. The resulting solution then moves to a Reactor where it reacts with finely crushed gypsum. Water is added to the reactor. The mixture then goes to a Vacuum filter, which produces a 25% $(\text{NH}_4)_2\text{SO}_4$ solution. This solution is then processed in a Crystal evaporator, followed by a Rotary dryer, to yield Crystalline $(\text{NH}_4)_2\text{SO}_4$.</p>	4	8
	<p>Ammonium Phosphate</p>		



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	<pre> graph LR NH3[Anhydrous liquid NH3] --> R1[Reactor 1] H3PO4[H3PO4] --> R1 R1 --> R2[Reactor 2] DryNH3[Dry NH3] --> R2 R2 --> Dryer[Dryer] Dryer --> Granulator[Granulator] Granulator --> Screen[Screen] Screen --> APG[Ammonium Phosphate Granules] </pre>	4	
<p>b)</p>	<p>Red Phosphorous and phosphoric acid</p> <p>Raw material: Phosphate rock, coke, sand</p> <p>Reaction: $2\text{Ca}_3(\text{PO}_4)_2 + 10\text{C} + 6\text{SiO}_2 = \text{P}_4(\text{Yellow}) + 6\text{CaSiO}_3 + 10\text{CO}$ $\text{P}_4(\text{Yellow}) + \text{heating} = \text{P}_4(\text{Red})$</p> <p>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.</p> <p>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°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 electrostatic precipitator to remove dust and then water cooled condenser. Liquid yellow phosphorous is collected under water. CO obtained is used as</p>	4 marks for flowsheet and 4 for descriptio n	8

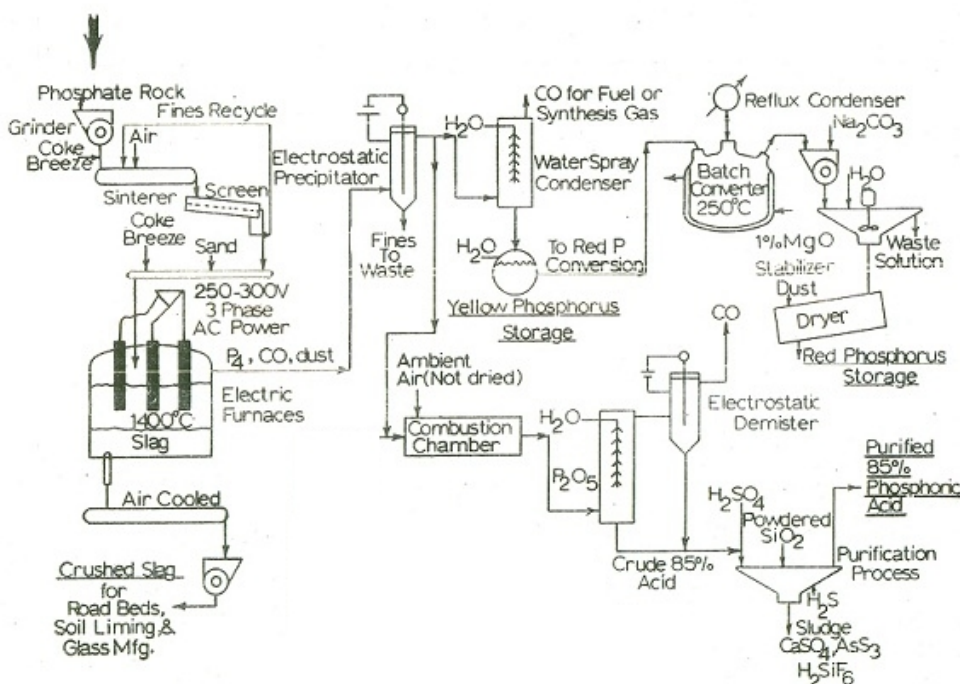
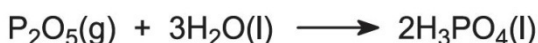
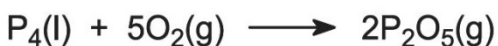


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fuel. Molten slag obtained from furnace can be used as raw material for furnace.

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.

Phosphorous is oxidized and reacted with water to produce phosphoric acid.



Note: Marks should also be given to those who have made separate flow sheets for red phosphorus and phosphoric acid.



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c)	<p>Solvay process</p> <p>The overall reaction can be regarded as between calcium carbonate and sodium chloride:</p> $\text{CaCO}_3 + 2\text{NaCl} \longrightarrow \text{CaCl}_2 + \text{Na}_2\text{CO}_3$ <p>However, calcium carbonate is too insoluble to react with a solution of salt. Instead the product is obtained by a series of seven stages.</p> <p>The process is known as the ammonia-soda process or the Solvay process, named after the Belgian industrial chemist who patented it in 1861. The various stages of the Solvay process are interlinked as can be seen from the diagram and description below.</p> <p>(1) Ammoniation of brine</p> <p>Ammonia gas is absorbed in concentrated brine to give a solution containing both sodium chloride and ammonia. $\text{Na}^+(\text{aq})$, $\text{Cl}^-(\text{aq})$, $\text{NH}_4^+(\text{aq})$, $\text{OH}^-(\text{aq})$ ions and $\text{NH}_3(\text{aq})$ are present.</p> <p>(2) Formation of calcium oxide and carbon dioxide</p> <p>Kilns are fed with a limestone/coke mixture (13:1 by mass). The coke burns in a counter-current of pre-heated air:</p> $\text{C}(\text{s}) + \text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) \quad \Delta H^\ominus = -393 \text{ kJ mol}^{-1}$ <p>The heat of combustion raises the temperature of the kiln and the limestone decomposes:</p> $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \quad \Delta H^\ominus = +180 \text{ kJ mol}^{-1}$ <p>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).</p>	Reaction-2 Diagram-3 Process-3	8
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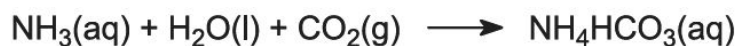
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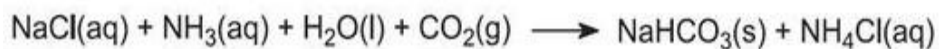
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(3) The Solvay Tower

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:



The solution now contains ions $\text{Na}^+(\text{aq})$, $\text{Cl}^-(\text{aq})$, $\text{NH}_4^+(\text{aq})$ and $\text{HCO}_3^-(\text{aq})$. 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:



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:



The carbon dioxide is sent back to the Solvay Tower for use in step



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(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:



(7) Regeneration of ammonia

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



The ammonia is thus recovered, and sent back to step (1). Calcium chloride is the only by-product of the whole process.

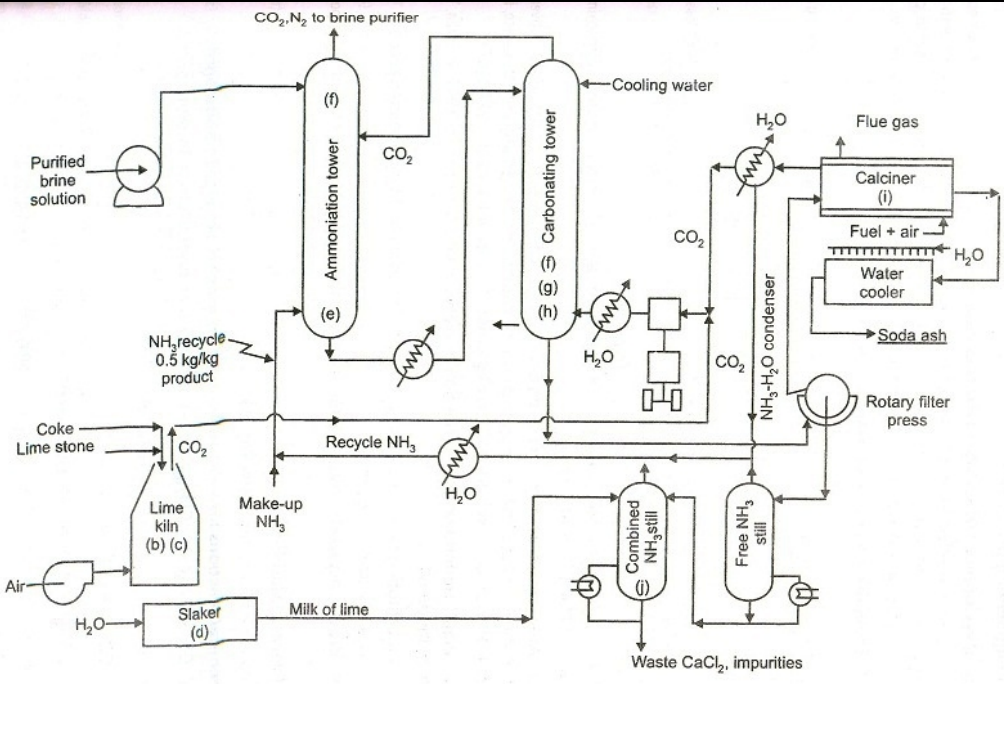
The overall process is an elegant one. In theory, the only raw materials are limestone and brine. Inevitably, there are losses of ammonia, and these are made up for by addition of extra supplies, as required in step (1).



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Q3 a)	<p>Chemical reactions for superphosphate</p> $[\text{Ca}_3(\text{PO}_4)_2]_3\text{CaF}_2 + 7\text{H}_2\text{SO}_4(\text{aq}) \rightarrow$ <p>Phosphate rock $3\text{CaH}_4(\text{PO}_4)_2 + 7\text{CaSO}_4 + 2\text{HF}$ Superphosphate</p> <p>Triple superphosphate</p> $[\text{Ca}_3(\text{PO}_4)_2]_3\text{CaF}_2 + 14\text{H}_3\text{PO}_4 + 10\text{H}_2\text{O} \rightarrow$ <p>Phosphate rock $10\text{CaH}_4(\text{PO}_4)\text{H}_2\text{O}$ Triple Superphosphate</p>	2	4
b)	Yellow phosphorus is converted to red phosphorus in covered retorts containing a reflux condenser to retain any evolved P_4 vapour. The vessel is	4	4



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	<p>gradually heated and the contents melt and slowly change to red phosphorus. This mass solidifies when approx. 70% has been converted. Since this reaction is exothermic, heat control must be applied to avoid bumping. After a cycle of 6-8 hrs the solidified mass is cooled, chipped out, washed with aq. Na_2CO_3 and water to remove residual and unstable P_4 then dried stabilized with 1% MgO.</p>		
c)	<p>Manufacturing of PCl_3</p> <p>low sheet for manufacturing of phosphorus trichloride (PCl_3)</p>	4	4
d)	<p>Cell reactions involved in mercury cell & Diaphragm cell</p>		4



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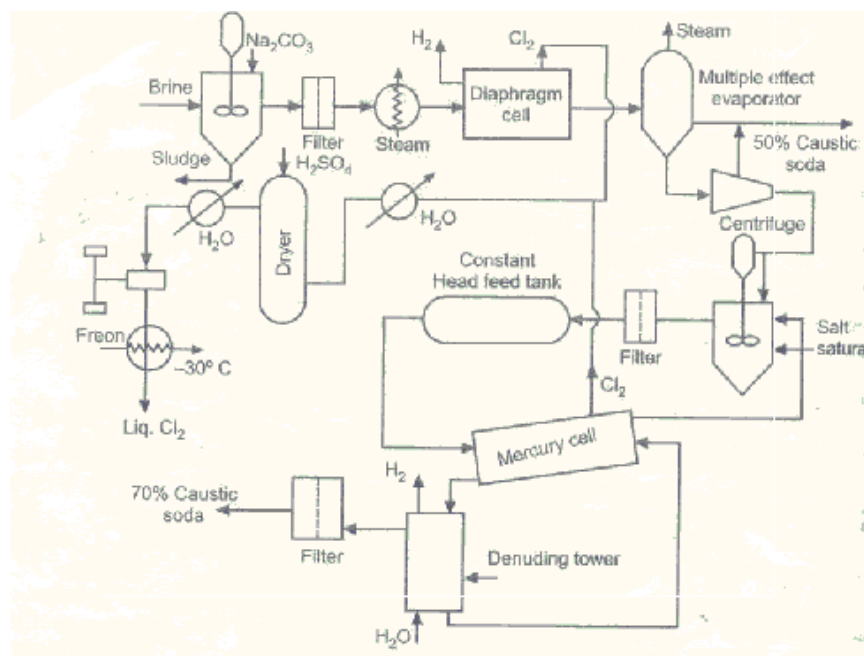
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	<p>Reaction :</p> <p>(a) Diaphragm cell : Cell notation</p> <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">Anode</td> <td style="text-align: center;">Cathode</td> </tr> <tr> <td style="text-align: center;">$\uparrow \text{Cl}_2, \text{C} \mid \text{NaCl (aq)}$</td> <td style="text-align: center;">$\text{NaOH (aq)} \mid \text{Fe, H}_2 \uparrow$</td> </tr> </table> <p>Cell reaction :</p> <p>Anode : $\text{Cl}^- - \text{e}^- \rightarrow \frac{1}{2} \text{Cl}_2$</p> <p>Cathode : $\text{Na}^+ + \text{H}_2\text{O} + \text{e}^- \rightarrow \text{Na}^+ + \text{OH}^- + \frac{1}{2} \text{H}_2$</p> <p>Overall : $\text{NaCl} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \frac{1}{2} \text{H}_2 + \frac{1}{2} \text{Cl}_2$</p> <p>(b) Mercury cell : Cell notation</p> <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">Anode</td> <td style="text-align: center;">Cathode</td> </tr> <tr> <td style="text-align: center;">$\uparrow \text{Cl}_2 \mid \text{C, NaCl (aq)}$</td> <td style="text-align: center;">$\text{Na}^\circ \mid \text{NaHg}$</td> </tr> </table> <p>Cell reaction :</p> <p>Anode : $\text{Cl}^- - \text{e}^- \rightarrow \frac{1}{2} \text{Cl}_2$</p> <p>Cathode : $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}^\circ$</p> <p>Denuding : $\text{NaHg} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \frac{1}{2} \text{H}_2 + \text{Hg}$</p> <p>Overall : $\text{NaCl} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \frac{1}{2} \text{H}_2 + \frac{1}{2} \text{Cl}_2$</p>	Anode	Cathode	$\uparrow \text{Cl}_2, \text{C} \mid \text{NaCl (aq)}$	$\text{NaOH (aq)} \mid \text{Fe, H}_2 \uparrow$	Anode	Cathode	$\uparrow \text{Cl}_2 \mid \text{C, NaCl (aq)}$	$\text{Na}^\circ \mid \text{NaHg}$	2	
Anode	Cathode										
$\uparrow \text{Cl}_2, \text{C} \mid \text{NaCl (aq)}$	$\text{NaOH (aq)} \mid \text{Fe, H}_2 \uparrow$										
Anode	Cathode										
$\uparrow \text{Cl}_2 \mid \text{C, NaCl (aq)}$	$\text{Na}^\circ \mid \text{NaHg}$										
e)	<p>Mfg. Process of caustic soda</p> <p>Process description-</p> <p style="text-align: center;">Purified saturated brine is heated and electrolysed in a diaphragm cell. The cell operating at 45-55% decomposition efficiency, discharges 10-12% solution of caustic soda with about equal con. Of NaCl.</p> <p style="text-align: center;">Multiple effect evaporater concentrates the cell liquor to 50% NaOH</p>	2	4								



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solution The opted salt is separated,centrifuged,washed, then slurried with treated brine. Salt saturater 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 deg.C and collected as liquid chlorine



2

f) **Properties of chlorine**

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 oxidises, bleaches, disinfects.

Properties of HCl

2
(any2)

2

4



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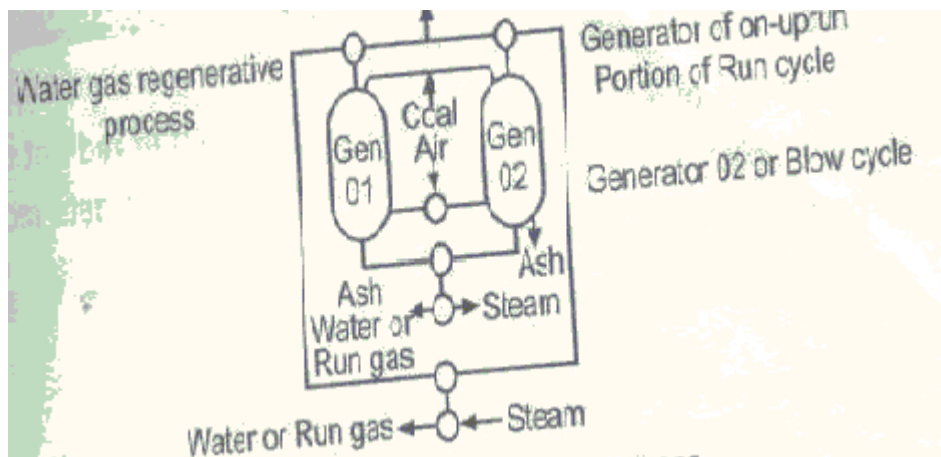
	<p>It is a colourless pungent gas with acidic test. Aqueous solutions are known as hydrochloric acid.</p> <p>It can be easily liquefied to a colorless liq. It reacts with metals their oxides, hydroxides It is stable and can be oxidised by strong oxidising agents like manganese dioxide etc</p>	(any2)	
Q 4 a)	<p>Use of NaOH</p> <ul style="list-style-type: none">• Soap making,• in the production of alumina,• in paints and varnishes,• in petroleum refining,• in the mfg. Of artificial silk.	1 mark for each	4
b)	<p>Chemical reaction involved in pollution control for single super phosphate</p> <p>i) $4\text{HF} + \text{SiO}_2 \rightarrow \text{SiF}_4 + 2\text{H}_2\text{O}$</p> <p>ii) $3\text{SiF}_4 + 2\text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SiF}_6 + \text{SiO}_2$</p> <p>iii) $\text{H}_2\text{SiF}_6 + 2\text{NaCl} \rightarrow \text{Na}_2\text{SiF}_6 + 2\text{HCl}$</p>	4	4
c)	<p>Grades of P₄</p> <p>Yellow phosphorus, red phosphorus, scarlet phosphorus, violet phosphorus and black phosphorus</p>	4	4
d)	<p>Uses of soda ash</p> <p>Used in inorganic chemical industry for producing other soda products and number of inorganic salts. It is also used in metallurgy, in glass industry for petroleum products, in pulp & paper, paint & varnish</p>	1 mark each for any four	4
e)	<p>Mfg. of water gas</p> <p>Regenerative process</p>		4



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2

Process description-

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, CO₂, CO are allowed to pass into the atmosphere.

2

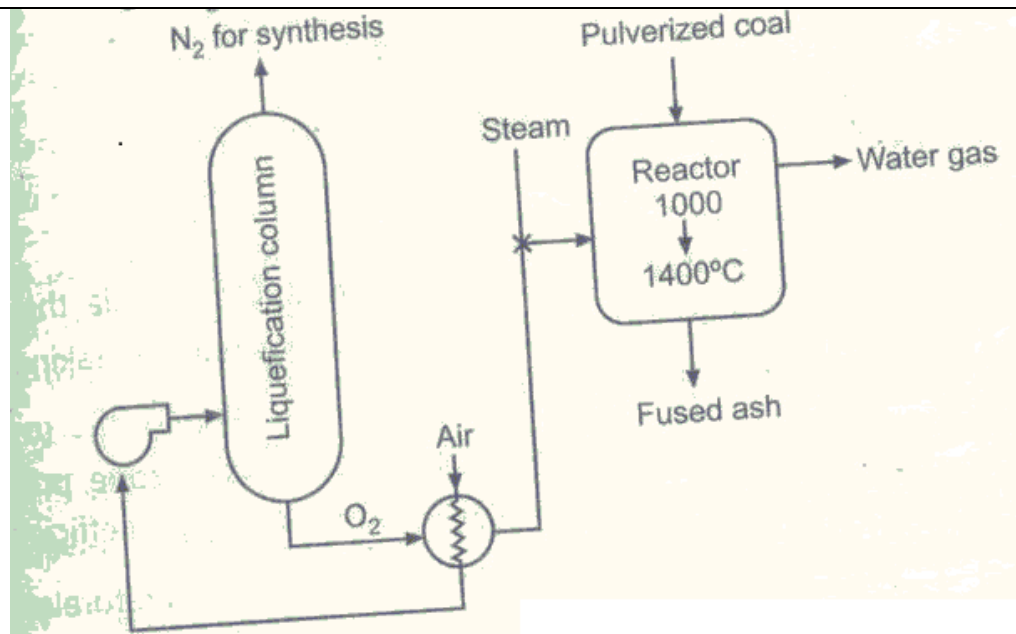
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Continuous process

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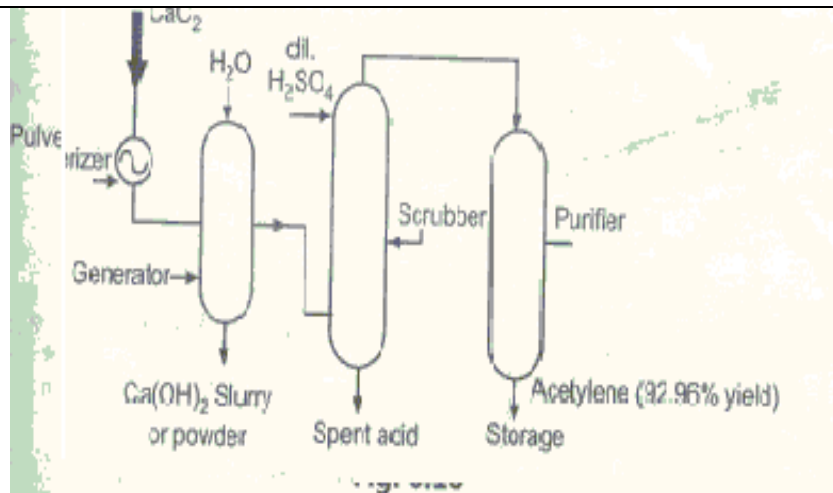
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Process description

The correct ratio of steam ,oxygen and coal is added to reactor to the yield water gas as shown in the dig.

f)



4

4

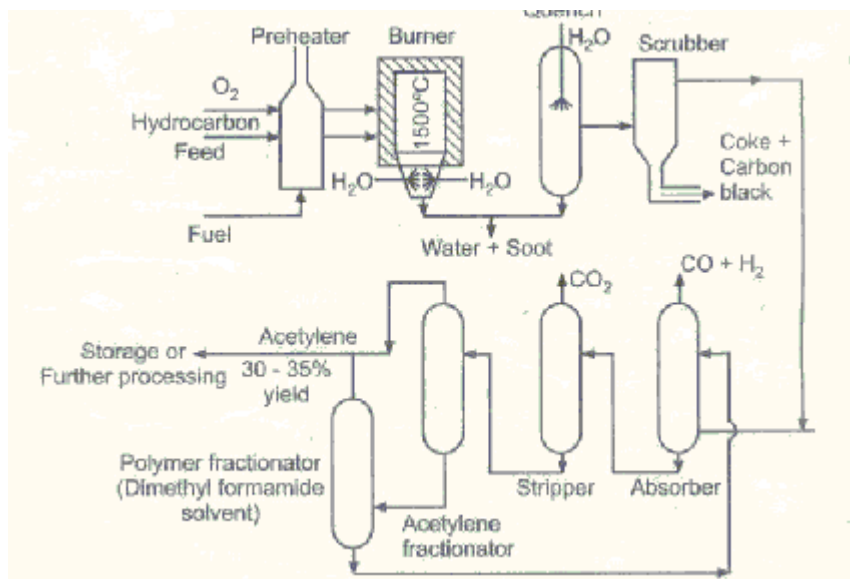


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OR



Q5 a) **Manufacturing of nitric acid:**

Ammonia is vaporized either by steam or some other energy. The NH_3 vapours are thus mixed with hot air. Air is preheated by nitrogen oxide. NH_3 content is 9.5-11% in the mix.

The mix. is filtered & send to bed of catalyst consisting of 90% platinum & 10% Rhodium at a temp of greater than $750\text{-}800^\circ\text{C}$. Nitrous oxide go to preheater & then to waste heat boiler where temp is reduced to $179\text{-}199^\circ\text{C}$.

Then the gases are further passed through series of coolers . Nitrous oxide from condenser are send to series of absorption towers for oxidation & scrubbing to give weak HNO_3 . The temp of nitrous gases approach to that of cooling water. The make up of water & dilute condensate from first cooler is added at the top of absorption

4 marks
for
flowsheet
and 4 for
descriptio
n

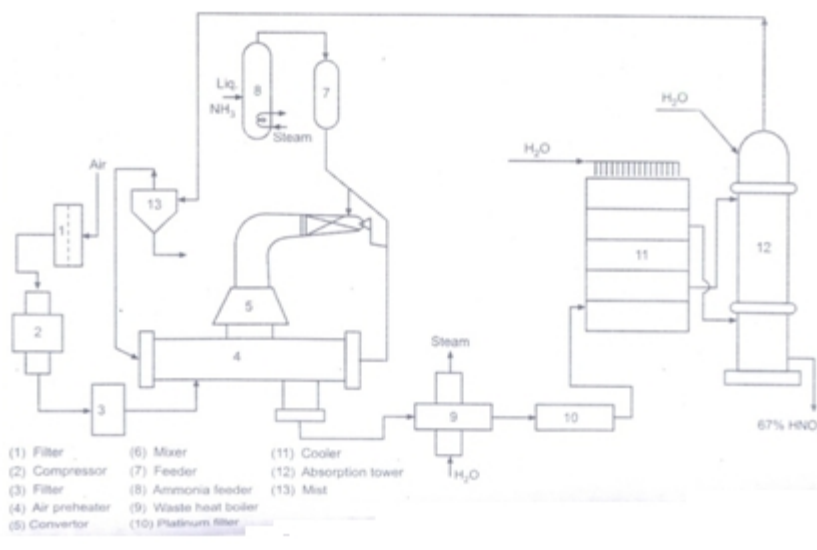
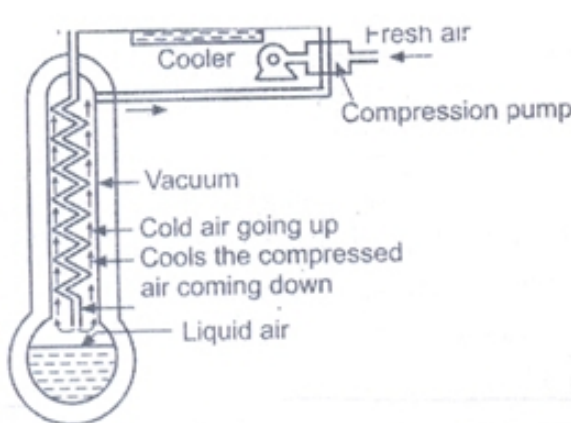
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	<p>tower to yield conc.HNO₃.</p>  <p>(1) Filter (6) Mixer (11) Cooler (2) Compressor (7) Feeder (12) Absorption tower (3) Filter (8) Ammonia feeder (13) Mist (4) Air preheater (9) Waste heat boiler (5) Converter (10) Platinum filter</p>		
<p>b) Lindes Process Pressure: 200atm Temp: -195.80C for Nitrogen & -182.950C for Oxygen.</p>	 <p>Fresh air Cooler Compression pump Vacuum Cold air going up Cools the compressed air coming down Liquid air</p>	<p>2 2 4</p>	<p>8</p>
<p>c)</p>	<p>Name of mixed fertilizer: 1.NPK complex</p>	<p>1 mark</p>	<p>8</p>



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	<p>2.Nitrophosphate 3. Diammonium phosphate 4.Ammonium phosphate sulphate etc</p> <p>(name of any fertilizer which contain at least two component from N,P&K) N.P.K. means Nitrogen,Phosphorus & Potassium</p> <p>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 effects like acidity will not be there. Usually mixed fertilizer are prepared to suit a group of crops and soils</p>	<p>each for any 2</p> <p>2</p> <p>4</p>	
Q6 a)	<p>Application of Acetylene:</p> <ol style="list-style-type: none">1. Acetylene is employed with oxygen to give highest welding & cutting temp.2. It is used in the manufacture of vinyl chloride, neoprene ,vinyl acetate3. It is also used for the manufacture of acetaldehyde, ethanol, hexachloro ethane.4. Acetylene is used as a key component in low pressure carburizing. It provides the precise carbon source automotive manufacturers need to create a strong, wear-resistance surface layer on steel parts.	<p>1 mark each</p>	4
b)	<p>Significance of C₂S,C₃S,C₃A,C₄AF IN Cement:</p> <ol style="list-style-type: none">1. Tricalcium Silicate (C₃S) hardens rapidly and is largely responsible for initial set and early strength. In general, the early strength of portland cement concrete is higher with increased percentages of C₃S.	<p>1</p>	4



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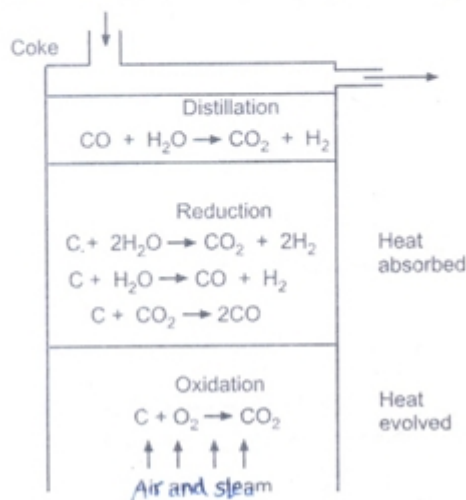
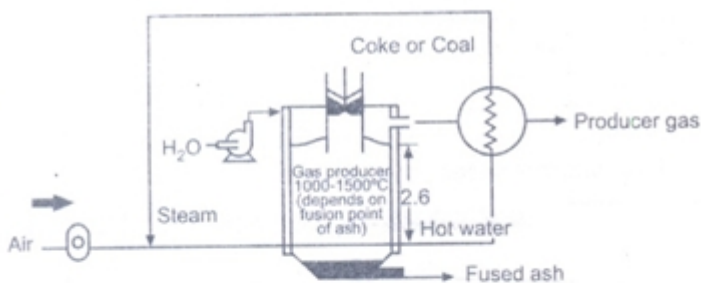
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	<p>2. Dicalcium Silicate (C_2S) hardens slowly and contributes largely to strength increases at ages beyond 7 days.</p> <p>3. Tricalcium Aluminate (C_3A) liberates a large amount of heat during the first few days of hardening and, together with C_3S and C_2S may somewhat increase the early strength of the hardening cement (this effect being due to the considerable heat of hydration that this compound evolves). It does affect set times.</p> <p>4. Tetracalcium Aluminoferrite (C_4AF) contributes very slightly to strength gain. However, acts as a flux during manufacturing. Contributes to the color effects that makes cement gray.</p>	<p>1</p> <p>1</p> <p>1</p>	
c)	<p>Methods of separation of azeotropic mix of nitric acid are as follows:</p> <p>1. The first method consist of mixing the 60% HNO_3 with strong H_2SO_4 (93%) . the mixing is carried out in silicon –iron or stoneware towers. The vap. Leaving the tower are 90% nitric acid or more & the bottom consist of dilute 70-7% sulfuric acid. This dil. Sulfuric acid may be recommended or used for making superphosphate fertilizer.</p> <p>2. In second method aq.solution containing 79% magnesium nitrate is fed to the middle of tower along with dil. HNO_3(about 60%). The salt solution act as an extractive distillation agent. About 55% magnesium nitrate is removed from the base of tower. After reconcentration to 72% , the magnesium nitrate is recirculated to the nitric acid tower. Pure HNO_3 of 95-98% strength is taken overhead.</p>	<p>2</p> <p>2</p>	4
d)	<p>Producer gas</p> <p>Chemical reactions:</p> $C + O_2 \rightarrow CO + 97000\text{kcal}$ $CO_2 + C \rightarrow 2CO - 91000\text{cal}$ $H_2O(\text{Steam}) + C \rightarrow H_2O + CO - 30900\text{cal}$ $2H_2O + C \rightarrow 2H_2 + CO_2 - 20820\text{cal}$	<p>2</p>	4



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e) **Superphosphate** has neutral effect on the soil. The continuous use of superphosphate helps to improve the soil conditions by neutralizing toxic compounds present in soil. Superphosphate is an ideal fertilizer for capital or maintenance applications. It is an excellent source of three plant nutrients. The P component reacts in soil similarly to other soluble fertilizers. The presence of both P and sulfur (S) in Superphosphate can be an agronomic advantage where both of these nutrients are deficient. In agronomic studies where Superphosphate is demonstrated to be superior to other P fertilizers, it is usually due to the S and/or Ca that it contains. When locally available,

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	<p>Superphosphate has found wide-spread use for fertilizing pastures where both P and S are needed. As a source of P alone, Superphosphate often costs more than other more concentrated fertilizers, therefore it has declined in popularity.</p>		
f)	<p>Advantages of DCDA process over conventional process:</p> <p>The next step to the Contact Process is DCDA or Double Contact Double Absorption. In this process the product gases (SO_2) and (SO_3) are passed through absorption towers twice to achieve further absorption and conversion of SO_2 to SO_3 and production of higher grade sulfuric acid.</p> <p>SO_2-rich gases enter the catalytic converter, usually a tower with multiple catalyst beds, and are converted to SO_3, achieving the first stage of conversion. The exit gases from this stage contain both SO_2 and SO_3 which are passed through intermediate absorption towers where sulfuric acid is trickled down packed columns and SO_3 reacts with water increasing the sulfuric acid concentration. Though SO_2 too passes through the tower it is unreactive and comes out of the absorption tower.</p> <p>This stream of gas containing SO_2, after necessary cooling is passed through the catalytic converter bed column again achieving up to 99.8% conversion of SO_2 to SO_3 and the gases are again passed through the final absorption column thus resulting not only achieving high conversion efficiency for SO_2 but also enabling production of higher concentration of sulfuric acid.</p> <p>The industrial production of sulfuric acid involves proper control of temperatures and flow rates of the gases as both the conversion efficiency and absorption are dependent on these.</p>	4	4