



Summer-16 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 one equivalent concept.



Q No.	Answer	Marks	Total marks
1	Attempt any six		12
a)	Methods for production of pulp Mechanical Chemical:- Kraft, Sulphite Semi chemical	1/2 1 1/2	2
b)	Non edible oil (Any two) Jatropha oil Castor oil Neem oil Karanja oil Edible oil (Any two) Ground nut oil Sunflower oil Soybean oil Coconut oil Mustard oil	½ Mark each for two from each type	2
c)	Enzymes used in alcohol manufacturing Invertase zymase	1 mark each	2
d)	Vinegar is a liquid consisting of about 5–20% acetic acid (CH ₃ COOH), water, and other trace chemicals, which may include flavorings.	2	2
e)	Saponification value It is the no. of milligrams of KOH required to saponify one gram of an oil or fat.	2	2



f)	Acid Value It indicates the quality of oil. It is important to know while storing oil in metal tanks. It is important to know while using in engines to avoid corrosion problem.	1 mark each for any 2	2
g)	Basis Weight (GSM) The weight or substance per unit area is obviously fundamental in paper and paper board products. The Basis weight of paper is the weight per unit area. This can be expressed as the weight in grams per square metre (GSM or g/m ²), pounds per 1000 sq. ft. or weight in kgs or pounds per ream (500 sheets) of a specific size. REAM WEIGHT is a common term to signify the weight of a lot or batch of paper. Control of basis weight is important as all other properties are affected. A variation in moisture content in paper affects the grammage.	2	2
1B	Attempt any two		8
a)	Polymerization process The no. of monomers are joined together to form polymer the process is known as polymerization. Types of polymerization process 1) Addition polymerization eg. Polyethylene, polystyrene 2) Condensation polymerization eg. Phenol formaldehyde	2 2	4
b)	Constituents of paint Pigments: - It is finely divided solids generally made up metal oxides .It is used to give colour to paint. Drying oil: - These are unsaturated oils. It is used to form protective film and give gloss. Thinners or solvent: - It is alcohols or turpentine. is used to dissolve	1 mark each	4



	<p>polymers in paint and to disperse pigments (emulsion formation).It adjust viscosity, form thin film.</p> <p>Plasticizer: - These are polymers. Used to impart elasticity to paint.</p>		
c)	<p>Hydrogenation of Oil</p> <p>The diagram illustrates the hydrogenation process. It starts with an oil feed entering a hydrogenator where H₂ and a catalyst oil slurry are added. The hydrogenator also receives steam or water. The output goes to a vacuum steam decolorizer, which has a barometric leg and is heated by steam. The decolorizer is followed by a decolorization stage using filter aid, fullers earth, and carbon. The final product is Product Oil, specifically Vanaspoti or Partially Hydrogenated Oil. A recycle catalyst loop is shown where catalyst is recovered and reused.</p>	4	4
2	Attempt any four		16
2 a)	<p>Manufacturing process of acetic acid from acetaldehyde</p> <p>The continuous oxidation of CH₃CHO in liq. phase is carried out by using air or O₂ in presence of manganous acetate. The reaction mix containing CH₃CHO diluted with crude acid & manganous acetate solution is circulated upward through oxidation tower. Reaction condition when air is used 55°C-65°C & 5 atm. Press and when O₂ used then temp 700c-800c and press sufficient to keep the acetaldehyde in liq.state. The reaction mix is drawn off from top of oxidation tower and distilled continuously in three distillation columns. The crude acetic acid is fed to the top of distillation column and</p>	4	4

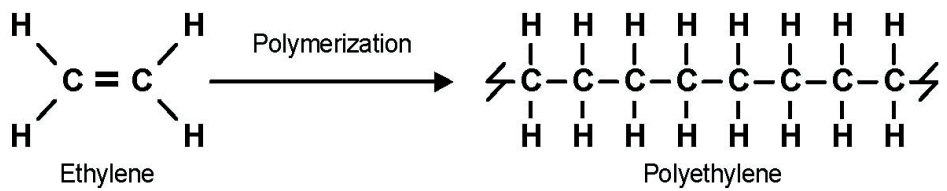


	other volatile components are withdrawn as overhead and residue containing manganous acetate is removed at the bottom.		
b)	<p>Decorative and building paints</p> <ol style="list-style-type: none">1. Flat wall paints2. Floor paints3. Masonry finish paint4. Fire resisting paint <p>Industrial paint</p> <ol style="list-style-type: none">1. Chlorinated rubber paint2. Ship paint3. Automobile paint4. Antifouling paint	1 mark each for any 4	4
c)	<p>Production of paper from pulp</p>	4	4

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d)	Various Methods for phenol manufacturing <ol style="list-style-type: none">1. Cumene peroxidation – hydrolysis2. Toluene two – stage oxidation.3. Rasching : vapour phase hydrochlorination & hydrolysis.4. Chlorobenzene - caustic hydrolysis.5. Benzene sulfonate – caustic fusion.6. Benzene – direct oxidation.	1 each for any four method s	4
e)	Polyethylene (Reaction)  <p>Process</p> <p>a .High Pressure Process : This process was developed in the UK by ICI. It uses peroxide catalyst at 100-300°C and produces low density randomly oriented polymer which have a low melting point. The process is run at pressure of 1000 – 2500 atms. This process yields Low Density Polyethylene (LDPE).</p> <p>b .Intermediate Pressure Process : This process was developed in the USA by Phillips Petroleum Co. for preparing high density polymer with increased rigidity, crystallinity, tensile strength and softening point. The process uses MoO₃ and Cr₂O₂ on alumina as catalyst and is operated at 30 – 100 atms.</p> <p>c .Low Pressure Process : This process was originally developed in Germany for preparing high density polyethylene (HDPE). The catalyst used in this process consists of aluminium triethyl activated with heavy metal derivatives such as TiCl₄.</p> <p>d. Low Pressure Ziegler Process to produce polyethylene.</p>	1 mark for reaction and 3 mark for any process	4



	<p>At the very onset, through the process of desulphurization and removal of light ends, high purity ethylene is prepared. The ethylene is further treated to remove traces of oxygen and its compounds which can possibly deactivate the catalyst.</p> <p>The ethylene is first pumped into a reactor where it is mixed with catalyst diluents stream. The optimum temperature and pressure maintained should be 70°C and 7 atms gage. The effluent stream then follows across a series of flash drums in order to remove the solvent from the catalyst. The residual catalyst at this point is removed by adding water.</p> <p>The flashed solvent is thereafter recycled to the catalyst make –up unit after appropriate drying and redistillation. The slurry which results is then centrifuged to remove the water, and the water is treated to remove the catalyst before recycle. The final products of polyethylene solids are then dried, extruded and given the required final forms.</p>		
f)	<p>By products of oil manufacturing</p> <ol style="list-style-type: none">1. Oil seed cake :- As animal feed pr low grade fertiliser2. Lecithin :- animal feed, chocolate, cosmetics3. Free Fatty Acid from refining :- Soap manufacturing, medicine4. Seed shells : As a fuel	1 mark each	4
3	Attempt any four		16
3 a)	<p>Manufacturing of butanol: Propylene is compressed to 250 atms. and cobalt naphtheanate added to give 0.5-1% Co in solution. This stream is passed concurrently through a packed tower containing a porous carrier with 2% metallic cobalt deposited. The reaction is highly exothermic and the temp. of 170 deg.C is controlled by recycle of a portion of the product stream after cooling.</p> <p>The liquid fraction is mixed with steam at 180 deg. C and a relatively low</p>	4	4



	<p>iii) Small quantities of sulfuric acid and emulsifying agents</p> <p>Phenol by cumene peroxidation process</p> <p>i) Toluene</p> <p>ii) Air</p> <p>iii) Small quantities of cobalt naphthenate and cupric benzoate catalyst.</p>	2	
e)	<p>Polyvinyl chloride</p> <p>Reaction</p> $\text{C}_2\text{H}_2 + \text{HCl} \rightarrow \text{CH}_2=\text{CHCl}$ <p>OR</p> $\text{CH}_2=\text{CH}_2 + \text{Cl}_2 \rightarrow \text{CH}_2\text{ClCH}_2\text{Cl}$ $\text{CH}_2\text{ClCH}_2\text{Cl} \rightarrow \text{CH}_2=\text{CHCl} + \text{HCl}$ <p>Vinyl chloride monomer can be polymerized to produce PVC</p> <p>Raw Material</p> <p>Vinyl chloride monomer (ethylene + chlorine)</p> <p>In emulsion polymerisation, a typical formulation is 100 parts of water, 100 parts of vinyl monomer, 1 part of catalyst persulfate and 1.5 parts of detergent emulsifier. This is fed to a pressure reactor, either cont. or batch operating at 50 deg. C for periods as long as 72 hrs. The micellular polymer particles can be further stabilised by addition of more emulsifying agent and solid as vinyl latex. For solid polymer, mixture acid coagulated and dried or spray dried</p>	1 1 1 1	4



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	directly.		
f)	<p>Polyester</p>	4	4
4	Attempt any four		16
4 a)	<p>Reactions involved in the mfg. of polystyrene</p> <p>The ethylbenzene is dehydrogenated catalytically in the gas phase at 650°C.</p> <p>Styrene is a water-white liquid which is readily polymerised.</p>	1 1.5 1.5	4
b)	<p>Types of varnishes</p> <p>i) Oil varnishes</p>	2	4



	<p>ii) Spirit varnishes</p> <p>Uses</p> <p>i) For protection of articles against corrosion</p> <p>ii) As a brightening coat to the painted surface</p> <p>iii) For improving the appearance and intensifying ornamental grains of wood surfaces,</p>	2	
c)	<p>Chemical reactions involved in the mfg. of alcohol from molasses</p> <p>Invertase</p> $\text{C}_{12}\text{H}_{22}\text{O}_{11} \xrightarrow{\text{yeast}} \text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6$ <p>sucrose yeast Glucose fructose</p> <p>zymase</p> $\text{C}_6\text{H}_{12}\text{O}_6 \xrightarrow{\text{yeast}} 2 \text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$ <p>Glucose or yeast</p> <p>Fructose Ethanol</p>	2 2	4
d)	<p>Cleansing action of soap</p> <p>A soap molecule has a polar end and a non-polar end .The polar end is water soluble while the non-polar end is oil soluble. Normally the water droplets in contact with water tend to coalesce to form oil layer and aqueous layer. The non polar ends of the soap molecule dissolve in the oil droplet leaving caroxylate ends projecting into the surrounding water. Due to the presence of negatively charged carboxylic groups, each of the oil droplets is surrounded by an ionic atmosphere. Oil droplets do not coalesce due to the repulsion between similar charges. Thus stable emulsion of oil in water is formed. In this way soap cleans by emulsifying the fat or grease containing dirt</p> <p>Soap forms a colloidal solution in water and thus removes dirt by absorption on its particle. Not only soaps, but any molecule containing polar</p>	4	4



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	ends and non-polar ends possess a cleaning property.														
e)	<p>Comparison between soap and detergents. (any four)</p> <table border="1"> <thead> <tr> <th>Soaps</th> <th>Detergents</th> </tr> </thead> <tbody> <tr> <td>1. Are sodium salts of long chain carboxylic</td> <td>Are sodium salts of long chain benzene sulphonic acids or alkyl</td> </tr> <tr> <td>2. Obtain by natural resources from plants and animals (fats, oils)</td> <td>Synthetic materials, hydrocarbon of petroleum or coal</td> </tr> <tr> <td>3. Calcium and magnesium salts are insoluble in</td> <td>Calcium and magnesium salts are soluble in water</td> </tr> <tr> <td>4. Produces scum in hard water which affects its cleaning</td> <td>Hard water does not affect its cleaning action</td> </tr> <tr> <td>5. Biodegradable</td> <td>Not too biodegradable</td> </tr> </tbody> </table>	Soaps	Detergents	1. Are sodium salts of long chain carboxylic	Are sodium salts of long chain benzene sulphonic acids or alkyl	2. Obtain by natural resources from plants and animals (fats, oils)	Synthetic materials, hydrocarbon of petroleum or coal	3. Calcium and magnesium salts are insoluble in	Calcium and magnesium salts are soluble in water	4. Produces scum in hard water which affects its cleaning	Hard water does not affect its cleaning action	5. Biodegradable	Not too biodegradable	1 mark each for any four	4
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f)	<p>Polyethylene by Ziegler Process</p>	4	4												
5	Attempt any two		16												



5 a)	<p>Manufacture of Alcohol from Molasses :</p> <p>i) Raw materials :</p> <p>1. Molasses (Black strap) :</p> <p>Molasses is considered as the mother liquor left after the removal of sugar crystals. Hence, it is a by-product of the sugar industry. It contains about 55% sugar (2/3 sucrose and 1/3 invert sugar.</p> <p>2. Yeast :</p> <p>i. Selected strains of saccharomyces cerevisiae :are commonly employed for fermentation. It produces a large amount of alcohol. Yeast is a source of different enzymes.</p> <p>ii. Preparation of inoculum :From the selected strains of yeast, the inoculum is prepared. The starter containing yeast is in its log phase. The yeast developed in a seed tank should be pure and free from contamination and mutation.</p> <p>iii. Preparation of medium :The molasses is difuted with water to 10 to 18%. These molasses can be used directly as fermentation medium. Nutrients such as ammonium sulphates or ammonium phosphate may be added to improve the quality of fermentation. The pH value of the medium is adjusted to 4 or 5 by adding sulphuric or lactic acid. Lactic acid is particularly beneficial as it inhabits the growth of butyric acid bacteria. pH below 5 inhibits lactic acid bacteria. Other possible microbial contaminants are inhibited by high sugar and alcohol concentration and the anaerobic condition of the fermentation. /as a result of these considerations, the molasses medium is not sterilized.</p> <p>iv. Fermentation : Alcoholic fermentation is an example of anaerobic fermentation. Fermentation has therefore to be carried out in the absence of</p>	3	8
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	<p>(1) Preparation of inoculum</p> <p>(2) Preparation of medium</p> <p>(3) Recoery of alchohol</p> <p>(4) Fermentation</p>	3	
b)	<p>Solvent extraction :</p> <p>Cakes obtained by pressing operations contain 5 – 10% oils. Further oil is extracted by heating the cake with volatile hydrocarbon like benzene. Petroleum ether, carbon disulphide or carbon tetrachloride are used for the extraction. The common solvent for edible oils is hexane or hexane type naphtha boiling in the range of 146 – 156 °F.</p> <p>In large-scale operations, solvent extraction is a more economical means of oil recovery than pressing by mechanical means.</p> <p>The use of chlorinated solvents mainly to decrease the explosion and fire hazard did not prove much satisfactory. The solvent used should not make the</p>	4	8

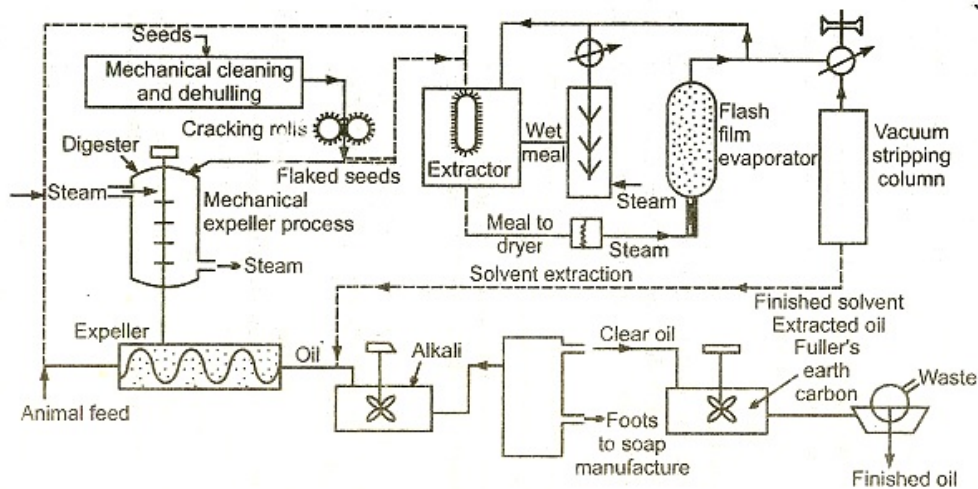


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oil toxic for the application.

Finally, organic solvent used for the extraction of oil is removed completely by distillation from the miscella (solvent and oil) to avoid objectionable odour to the oil. The resulting oil is then ready for use.

The extent of processing applied to oil or fat depends on their source, quality and ultimate use. Most of the fats are used for edible purposes with clarification by filter. Many cold pressed and virgin oils are used as food, directly. Peanut, coconut oils can be used directly without further processing. The growing demand for bland testing and stable salad oils and shortening led to extensive processing techniques. In less industrialized countries, processing is limited because of the lack of facilities and added costs.



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c)

Manufacturing of Phenol from Cumene

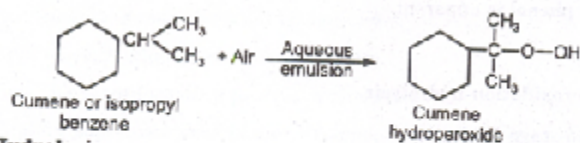
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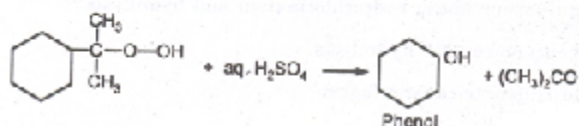
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(a) Peroxidation :



(b) Hydrolysis :



Process description: Cumene is mixed with recycle cumene & send to the hydrogenator. Unsaturated compounds are converted to saturated materials to avoid undesirable decomposition of the peroxide during the oxidation step. H₂ over nickel catalyst at 1000c in a batch reactor is used for purification. Oxidation is carried out in the presence of air in an aqueous emulsion stabilized by an alkali such as sodium carbonate in the 8.5-10.5 pH range. Vent gases are passed through a condenser to recover hydrocarbon.

The cumene peroxide thus formed is cleaved in an acidifier containing 10-25% H₂SO₄ . This is an agitated vessel at 55-650C . The reaction products are separated into an aqueous acid layer for recycle to the cleavage vessel and an oil layer containing 76 wt % cumene, 14% phenol, 8% acetone % 1-2% α - methyl styrene & acetophenone. This mix is separated in a series of four distillation steps, that last three of which are under vacuum. Phenol is the overhead of the last vacuum fractionator.

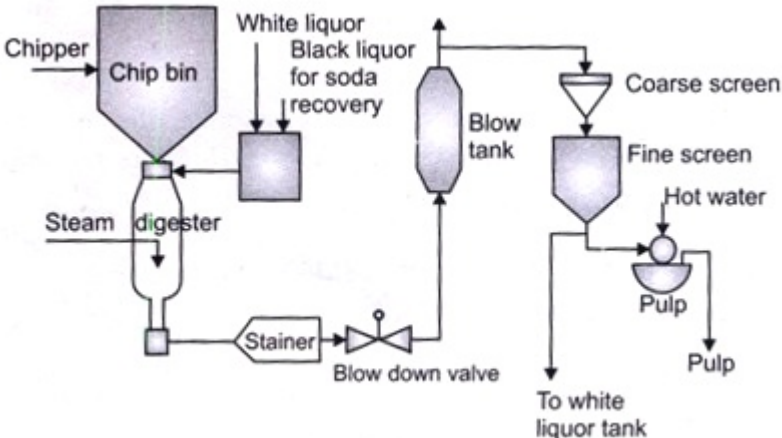
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2



	<p>The diagram illustrates the industrial process for the production of phenol from cumene. It begins with cumene and air entering an oxidizer, where alkali is added. The resulting mixture is then treated with H_2SO_4 in a cleavage stage. This is followed by a separator and a wash tower using acidified wash water to produce crude phenol. The crude phenol is then washed with H_2O. The remaining stream is processed in a vacuum distillation column to separate methyl styrene and cumene. The methyl styrene is further purified in another vacuum distillation column. The final products are phenol (via a crystallizer) and acetophenone. A cumene recycle stream is also shown.</p>	4	
6	Attempt any two		16
6 a)	Manufacturing of pulp from sulphate process <p>By means of rotary disk with many heavy knives reduce wood to 2-5 cm flat chips. The chips are metered by star valve to a deaerator-preheater. After several minutes the chips are discharged through a rotating tapered pulsed into lift line where recirculating digestion liquor at 12 atm pressure transfer chips to upper soaking zone of the 25-30 m tall digester tower.</p> <p>Chips are blown down past a series of circumferential screen plates. Cooking liquor is withdrawn as side stream and circulated through external heat exchanger to reheat and control the digestion temp within the tower.</p> <p>The digested chips are cooked at the base of tower by injection of black liquor. This is to avoid mechanical weakening of fibres from steam explosion of hot liquor when passed through blow down valve. The pulp liquor slurry is passed through a valve to a blow tank. The pulp is filtered to separate black liquor and screened to remove wood pieces and other undigested residue. Finally pulp is</p>	5	8



	<p>going to further processing.</p>  <p>The diagram illustrates the paper mill process. It starts with a Chipper feeding into a Chip bin. The chips then go to a digester where steam is added. The output goes to a Stainer, followed by a Blow down valve. The pulp then passes through a Blow tank, a Coarse screen, and a Fine screen. The final product is Pulp. There is also a section for White liquor and Black liquor for soda recovery, which feeds into the digester. A stream goes from the Blow tank to a white liquor tank.</p>	3	
b)	<p>Manufacture of poly styrene: Benzene is alkylated with ethylene in the presence of aluminum chloride. Dry benzene and ethylene are continuously fed to an alkylating tower operating at atm pressure. Small amount of ethylene chloride is added as a catalyst promoter .Granulated $AlCl_3$ is used as a catalyst. The crude ethyl benzene from settling tank is washed with 50% caustic solution to neutralize it.</p> <p>Purified ethyl benzene is heated with steam Sulfur is continuously mixed in the reactor. Crude styrene stream contains 37% styrene and 61% ethyl benzene. Styrene is obtained by distillation of this stream.</p> <p>Polystyrene production is carried out by free radical initiation or by coordinated catalyst. Bulk suspension and emulsion polymerizations are in use.</p> <p>In emulsion polymerization initiators are per-sulphates and emulsifiers are soap. Polymerisation is accomplished 3-5 m³ enamelled reactors fitted with water jacket stirrer and reflux condenser.</p>	2	8

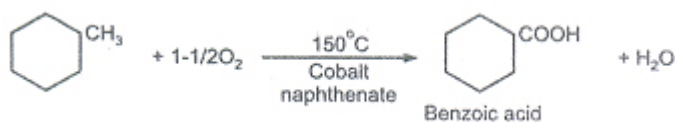
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	<p>The monomer is Suspended in aqueous phase using a stabilizer, sodium sulphate is added to control pH A thorough agitation keeps the monomer suspended in medium. The aqueous phase emulsified and mixed with monomer. The emulsion is sent into reactor which is kept & heated at 60 °C.</p> <p>The polymerization is carried out in nitrogen atm. Catalyst is added into the reactor. The reaction takes place for 3-6 hrs, after which sent into coagulator. The polymer formed the latex is separated by centrifugation. The polymer is washed & sent to drier.</p> $C_6H_6 + H_2C=CH_2 \rightarrow C_6H_5CH_2CH_3$ $C_6H_5CH_2CH_3 \rightarrow C_6H_5CH=CH_2 + H_2$ $C_6H_5CH=CH_2 + H_2 \rightarrow [C_6H_5-CH_2-CH_2-]_n$	2	
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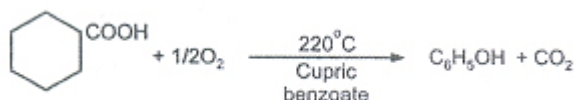


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		4	
c)	Phenol production		8

**Chemical reaction :****(a) Oxidation to benzoic acid :**

2

(b) Oxidation of benzoic acid to phenol :**Process Description :**

A two-stage air oxidation process is used. In the first stage, fresh plus recycle toluene are mixed with a small quantity of cobalt naphthenate catalyst and charged to the reactor which is a liquid-filled tower through which air is sparged. Cooling tubes are provided to remove the exothermic heat of reaction.

The reactor is run at 150°C and 3 atms. Excess air is used, but toluene conversion is limited to 40% to avoid excessive side reactions, These give by-products such as benzaldehyde, benzyl alcohol, benzyl benzoate, CO and CO₂. With conversion of toluene at 40% the ultimate yield of benzoic acid is about 90%.

Off-gases from the reactor are vented through a water-cooled condenser to remove water and to allow return of toluene. Liquid from the reactor continuously passes to a distillation column which strips the toluene and other volatile by-products from the acid fraction in the bottoms. Purified benzoic acid is separated by extracting the bottoms with hot water, then

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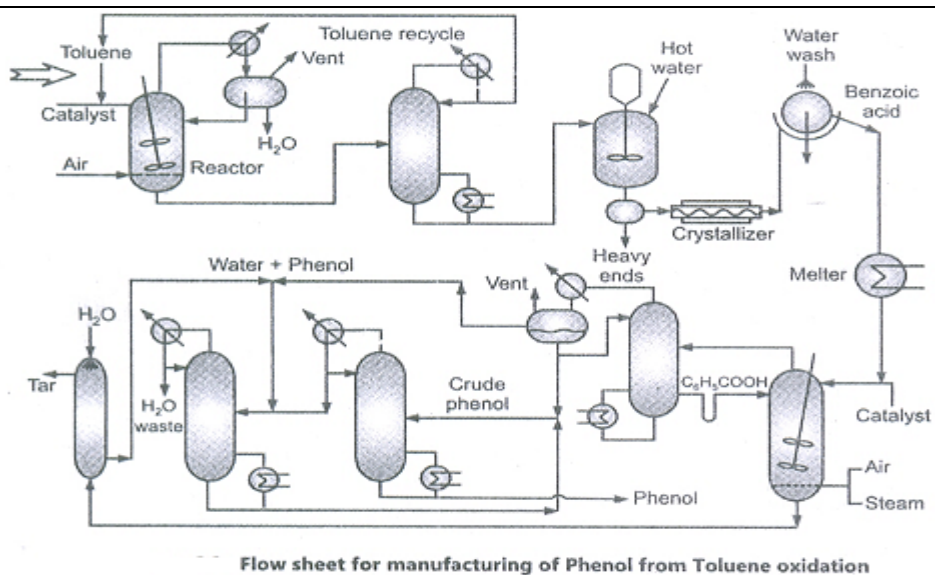
crystallizing and filtering the crude benzoic acid. The latter can be recrystallized to meet USP specifications as a market outlet for benzoic acid.

To make phenol, the crude acid is melted, mixed with cupric benzoate catalyst, then charged to an air-sparged tower containing cooling tubes and mechanical agitation,. Reactor conditions are 220°C and 13-17 atms. Excess air is again necessary to get a 70-80% conversion of benzoic acid with a yield of 90% phenol. The overall process yield for the two steps is about 80%.

Phenol product is obtained by continuously distilling the reactor liquor into a fractionating column where unreacted benzoic acid is returned to the reactor. Non-condensable such as N₂ O₂ and CO₂ are vented through a condenser along with the condensable fraction phenol-water. Phenol is withdrawn as the bottom layer in a separator. This crude phenol is again fractionated with purified phenol coming off as bottoms and the overhead phenol-water azeotrope sent to another column for splitting.

The heavy ends in the benzoic acid oxidation tower are water-extracted to recover phenol and benzoic acid which are then recycled, after concentration, to the second stage oxidation tower.

Flow Sheet :



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