WINTER–18 EXAMINATION

Model Answer

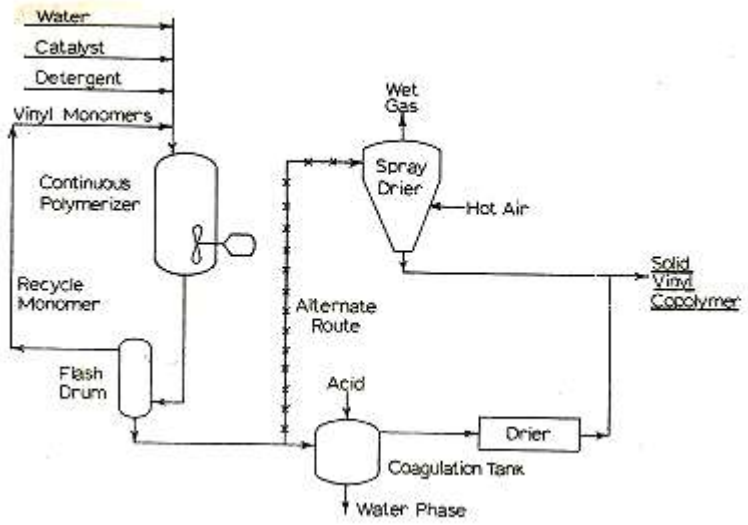
Subject Name: Chemical Process Technology-2 **Subject Code:** 17427

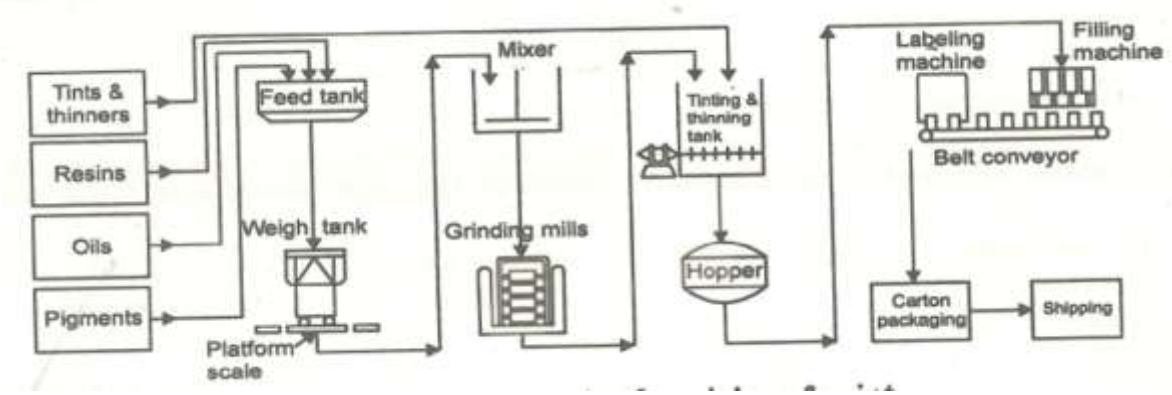
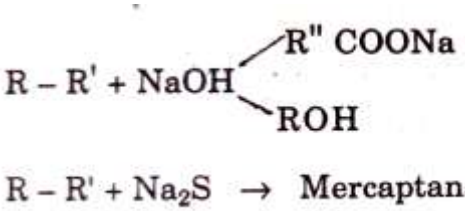
Important Instructions to examiners:

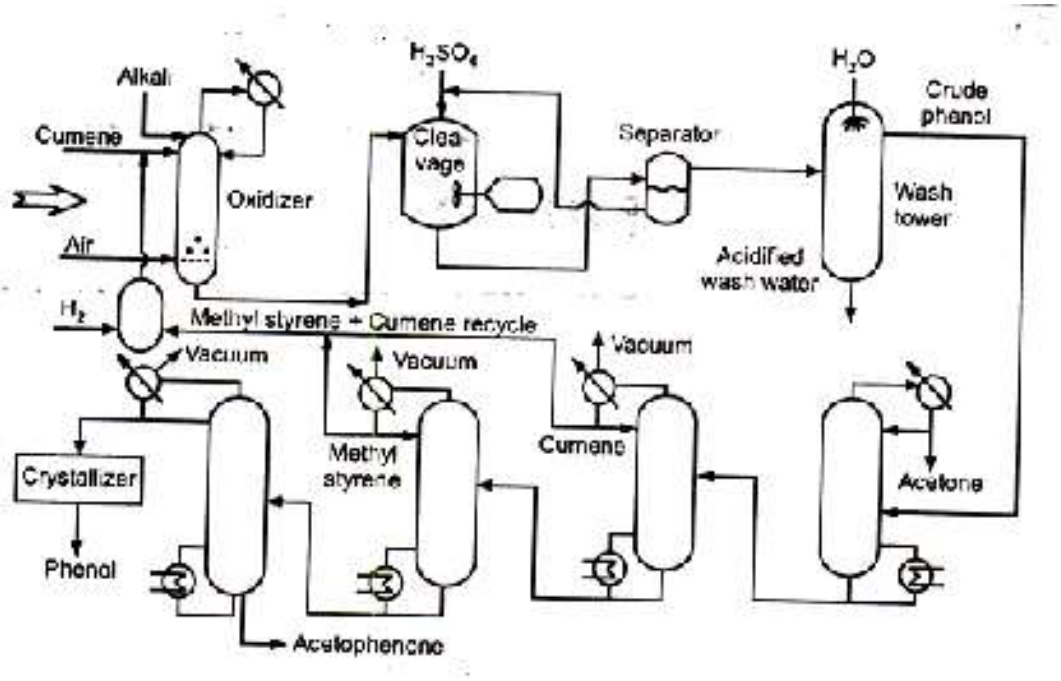
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 judgment 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	**A**	**Attempt any six**	**12**
	a)	**Raw material for Paper** Pulp from cellulose (bamboo, straw , bagasse etc) **Additives for improving quality of Paper** China clay Alkyl ketene dimer Epichloriohydrine Malamine Carboxymethyl cellulose Calcium carbonate	2
	b)	**Acid Value:** The acid number is defined as the number of milligram of KOH required to neutralize one gram of oil or fat. **Saponification value** It is the no. of milligrams of KOH required to saponify one gram of an oil or fat.	1 1
	c)	**Reaction for manufacturing of acetic acid by oxidation** $CH_3CHO + ½ O2 = CH_3COOH$	2

	d)	**Uses of Acetic Acid** For the production (any two) 1. Vinyl acetate monomer 2. Ester 3. Acetic anhydride 4. As a solvent 5. Medical 6. Food (vinegar) **Uses of Butanol** 1 . As a solvent 2. Paint thinner **3.** As potential fuel	½ mark each for any two ½ mark each for any two
	e)	**Hydrogenation oil** It is the reaction of oil with hydrogen gas. During hydrogenation, vegetable oils are reacted with hydrogen gas at about 60ºC. A nickel catalyst is used to speed up the reaction. The double bonds are converted to single bonds in the reaction. In this way unsaturated fats can be made into saturated fats – they are hardened.	2
	f)	**Methods of manufacturing of soap** 1. Batch process (cold process, hot process) 2. Continuous process	1 mark each
	g)	**Uses of Rayon** 1. Tire chord 2. Artificial hair 3. Bottle plugs 4. Fibers 5. Cellophane	1 mark each for any two uses
	B	**Attempt any two**	**8**
	a)	**PFD of PCV manufacturing by emulsion polymerization**	4

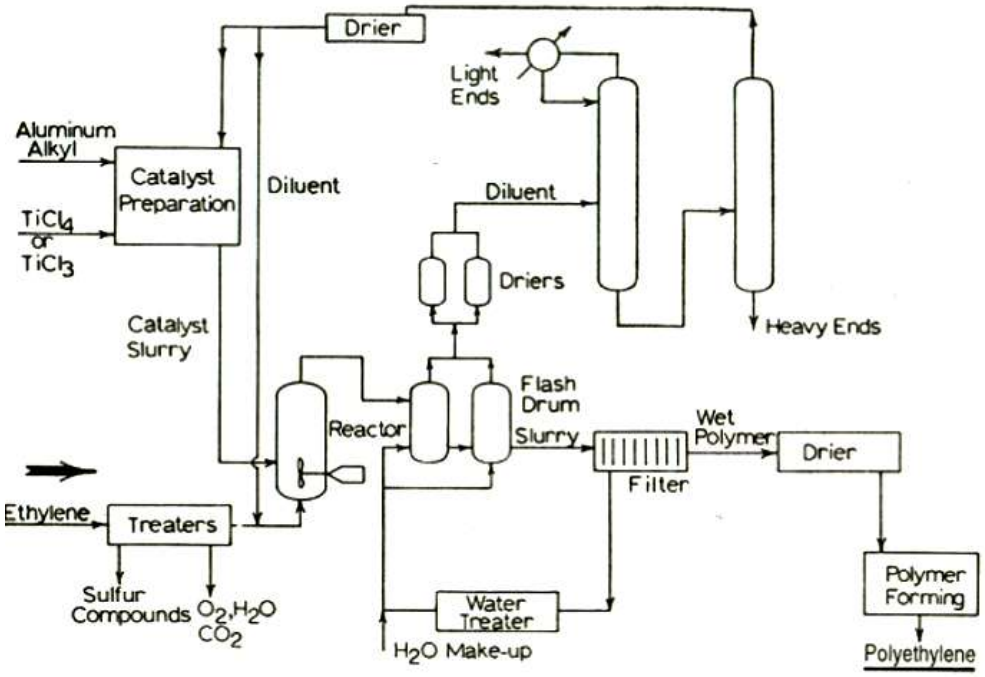
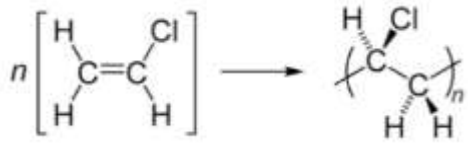
			
	b)	**Pigments constituents** White : Titanium oxide or zinc oxide Black : Carbon black Blue : Ultramarine (sulfur-containing sodio-silicate) Red: Cadmium red(Cadmium selenide)	1 mark each
	c)	**Comparison between soap and detergents.** **Soaps** / **Detergents** Soap is sodium salt of fatty acid / Are sodium salts of long chain benzene sulphonic acids or alkyl It is made from fats and oils / It is made from petrochemical It form scum in hard water / It form lather in hard water Soaps are more biodegradable / Detergents are less Soaps have lesser cleansing action or quality as compared to detergents. / Detergents have better cleansing action as compared to soaps.	1 mark each for any four differences
2		**Attempt any four**	**16**
	a)	**Oxo Process** Propylene is compressed to 250 atms and cobalt napthenate added to give 0.5-1 % Co in solution. This stream is passed co currently through packed tower containing porous carrier with 2% metallic cobalt deposited. The reaction is highly exothermic & temp. of 170 deg.C	4

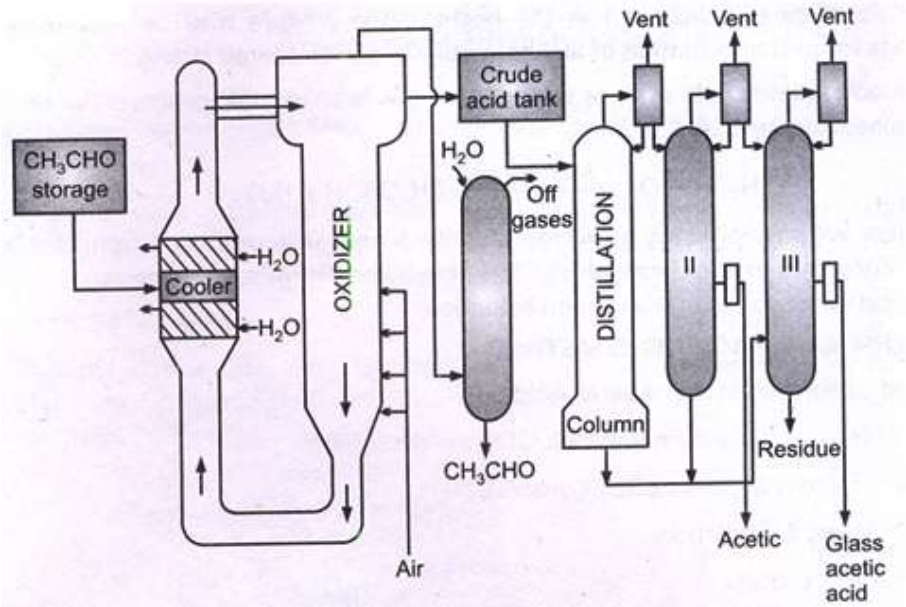
		is controlled by recycle of a portion of the product streams after cooling. The liquid fraction is mixed with steam at 180 deg.C & low pressure of 20atm.to decompose the Co carbonyl & naphthenate ,depositing the Co on porous carrier as the oxide. These CO is dissolved periodically in an acid wash & converted to the naphthenate for reuse. The unconverted synthesis gas from the oxo converter is recompressed & recycled. The crude butyraldehyde can be fractionated for product sale or continuously hydrogenated using fixed bed Ni catalyst,100 atm,H_2 press., & 150 deg.C. The resulting butanols are fed to distillation section comprising several fractionating columns in series. Light & heavy ends as by-product obtained in addition to the purified alcohol.	
	b)	**PFD for manufacturing of paint** 	**4**
	c)	**Raw material for pulp** Any material contain cellulose like bamboo, bagasse, caustic soda, sodium sulfate **Reaction (Sulfite process)** $SO_2 + H_2O = H_2SO_3 + Q$ $2H_2SO_3 + CaCO_3 = Ca(HSO_3)_2 + CO_2 + H_2O + Q$ **Reaction (Sulphate process)**  $R - R' + Na_2S \rightarrow$ Mercaptans	2 2 mark for any one process reactions

	d)	**Manufacturing of Phenol from Cumene**  	4
	e)	**Manufacturing of Polystyrene** **Raw material** Benzene and ethylene **Reactions** $C_6H_6 + H_2C=CH_2 \rightarrow C_6H_5CH_2CH_3$ $C_6H_5CH_2CH_3 \rightarrow C_6H_5CH=CH_2 + H_2$ $C_6H_5CH=CH_2 + H_2 \rightarrow [C_6H_5\text{-}CH_2\text{-}CH_2\text{-}]n$ **Uses (two)** disposable plastic cutlery and dinnerware, CD "jewel" cases, smoke detector housings, license plate frames, plastic model assembly kits	1 2 1
	f)	**Solvent extraction of oil** 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 ^oF.	4

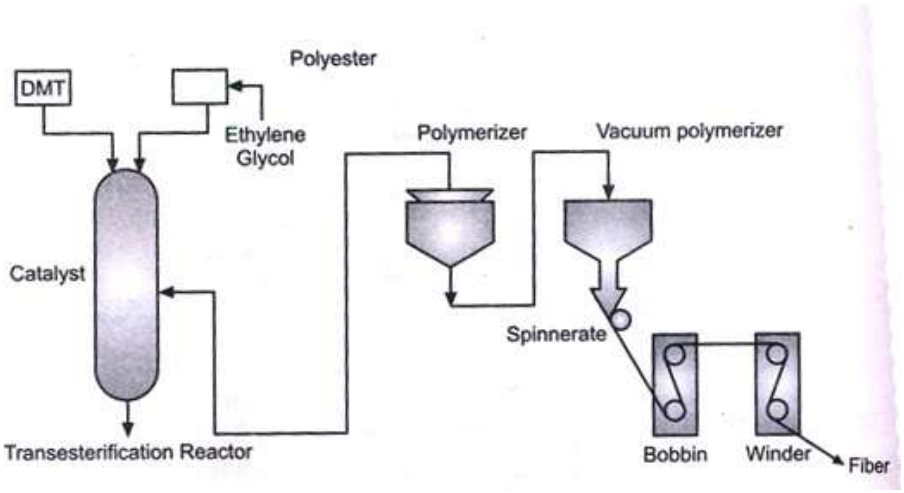
		In large-scale operations, solvent extraction is a more economical means of oil recovery than pressing by mechanical means. The use of chlorinated solvents mainly to decrease the explosion and fire hazard did not prove much satisfactory. The solvent used should not make the oil toxic for the application. 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.	
3		**Attempt any four**	**16**
	a)	**Ethyl alcohol from corn.** **Raw materials** Corn, Diastase, maltase, zymase **Reactions** $2\,(C_6H_{10}O_5)_n + n\,H_2O \xrightarrow{Diastase} n\,C_{12}H_{22}O_{11}$ $C_{12}H_{22}O_{11} + H_2O \xrightarrow{Maltase} 2\,C_6H_{12}O_6$ **Fermentation reaction** $C_6H_{12}O_6 \xrightarrow{Zymase} C_2H_5OH + 2\,CO_2$	1 3
	b)	**Raw materials for varnish** 1. Oil 2. Resins 3. Dryers **Steps in Manufacturing of oil Varnish**	2

<table>
<tr><td></td><td></td><td>1. Oil Varnishes are produced by dissolving resin in drying oil.
2. The Resin and oil are heated in a kettle to temperature of 250^{o}C to 320^{o}C.
3. The dryers and thinners are added if necessary. The mixture is then allowed to cool and then filtered.</td><td>2</td></tr>
<tr><td></td><td>c)</td><td>Difference between sulphate and sulphite process<table><tr><th>Sulphate Process</th><th>Sulphite Process</th></tr><tr><td>This process is alkaline in nature due to use of caustic and sodium carbonate</td><td>This process is acidic in nature due presence of sulfur dioxide.</td></tr><tr><td>Cooking chemicals are recovered from black liquor</td><td>Sulfur dioxide is recovered.</td></tr><tr><td>Pulp produced by the kraft process is stronger than that made by other pulping processes</td><td>Acidic sulfite processes degrade cellulose more than the kraft process, which leads to weaker fibers.</td></tr><tr><td>Fiber yield is less.</td><td>Fiber yield is more.</td></tr><tr><td>Comparatively difficult to bleach the pulp.</td><td>Can be bleached easily.</td></tr></table></td><td>1 mark for each point in both processes. (any four)</td></tr>
<tr><td></td><td>d)</td><td>Phenol production by Raschig process
The Raschig process has two vapour-phase catalyst stages. Purified benzene is fed to a heater, packed reactor containing ferric chloride & cupric chloride catalyst. Chlorination with HCl-O_2 at 220^{0}C occurs with a short residence time to produce 10-20% conversion of benzene. Fractionation separates unreacted benzene from chlorobenzene & polychlorobenzene.
The crude chlorobenzene is scrubbed with phenol, water washed & sent to the second catalytic stage. Here it is hydrolyzed in a tubular high temp furnace with either SiO_2 or $Ca_3(PO_4)_2$ as the catalyst. Phenol from the hydrolyzer is washed with water, then extracted by benzene & finally purified by two stage distillation. HCl vapours from the high temp catalytic hydrolyzer is recycled to the hydrochlorination stage</td><td>4</td></tr>
<tr><td></td><td>e)</td><td>Uses of
Polyethylene: Household utensils, packaging films, bottles, bucket, tubes, cable sheeting</td><td>1 mark each for</td></tr>
</table>

		storage tanks etc. *Polystyrene:* disposable plastic cutlery and dinnerware, CD "jewel" cases, smoke detector housings, license plate frames, plastic model assembly kits *Polyester:* Textile, fishing nets, filter cloth. Conveyor belt *Poly vinyl chloride:* Pipes, raincoats, cables, vinyl flooring	each type
	f)	**Ziegler process for the manufacturing of polyethylene**  	4
4		**Attempt any four**	**16**
	a)	**Reaction in PVC** **Monomer of vinyl chloride** $CH_2=CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$ $CH_2ClCH_2Cl \rightarrow CH_2=CHCl + HCl$ **Polymerization of VC** 	2

		Uses of PVC(any two) Pipes, raincoats, cables, vinyl flooring	2
	b)	**Raw material of paint (any two)** Pigments Drying oil Thinners or solvent Plasticizer Filler **Types of Paint (any two)** Industrial Paint Decorative Paint Marine Paint Water base paint Oil base paint	2 2
	c)	**PFD for manufacturing process of acetic acid from acetaldehyde** 	4

	d)	**Difference between hot and cold process** **Hot process** | **Cold process** High purity of soap is obtained. | Low purity of soap is obtained. Byproduct glycerol is separated. | Glycerol is mixed in soap Reaction temperature is high | Reaction temperature is low Maximum yield is possible. | Lesser yield is obtained.	1 mark for each difference
	e)	**Manufacturing of detergents**. The alkyl benzene is introduced continuously into sulfonator with the requisite amount of oleum, using the dominant batch principle. To control the heat of sulphonation conversion and maintain the temperature at about 55^{o}C. Into the sulfonation mixture is fed the fatty alcohol and more of the oleum. All are pumped through the sulfater , also operating on the dominant bath principle to maintain the temperature at 50-55^{o}C, thus manufacturing a mixture of surfactants. The sulfonated –sufated product is neutralized with caustic solution under controlled temperature to maintain fluidity of the surfactant slurry. The surfactant slurry, the sodium triphosphate, and most of the miscellaneous additives are introduced into the crutcher. A considerable amount of water is removed , and the paste is thickened by the tripolyposphate hydration reaction. This mixture is pumped into an upper story, where it is sprayed under high pressure into 24 meter high spray tower , counter to hot air from furnace. Dried granules are transferred to an upper story again by an air lift which cools them from 115^{o}C and stabilizes the granules. The granules are separated in cyclone separator, screened, perfumed and packed. **OR** Molten sodium is added slowly to coconut oil in an aliphatic solvent plus esterifying alcohol such as amyl alcohol. After certain time reaction is completed. The batch is pumped into a water tank where mixture settles into three layers, the top is the high molecular weight alcohols, the intermediate layer contains regenerated reducing alcohol, and the bottoms have caustic soda and glycerin for recovery. Lauryl alcohol is reacted with sulfuric acid to get sulfated fatty alcohol. It is one type of synthetic detergent.	4

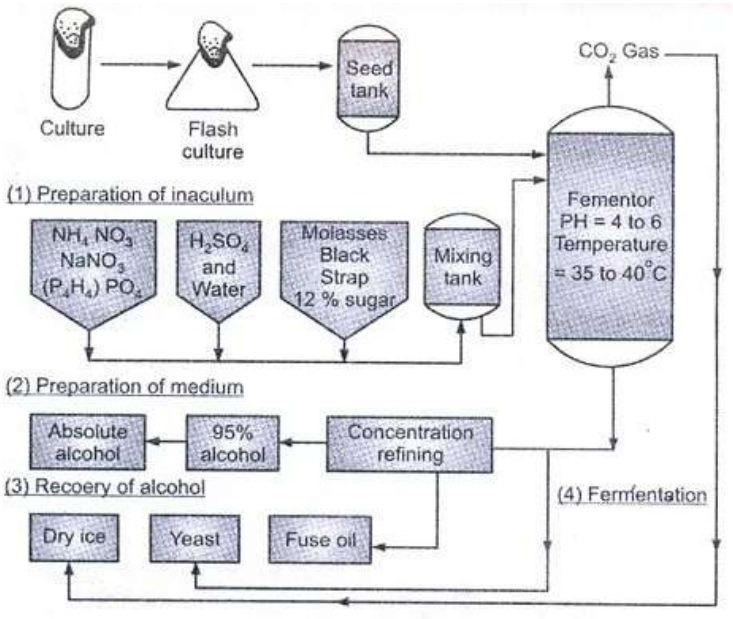
	f)	**PFD for manufacturing of polyester** 	4
5		**Attempt any two**	**16**
	a)	**Manufacture of Alcohol from Molasses :** **i) Raw materials :** **1. Molasses (Black strap) :** Molasses is considered as the mother liquor left after the removal of sugar crystals. Hence, it is a by-product of the sugar industry. It contains about 55% sugar (2/3 sucrose and 1/3 invert sugar. **2. Yeast :** **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. **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. **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	4

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.

iv. **Fermentation** : Alcoholic fermentation is an example of anaerobic fermentation. Fermentation has therefore to be carried out in the absence of oxygen. In alcoholic fermentation, the carbon dioxide produced pushes out air and automatically creates an anaerobic atmosphere. The fermentation reaction being exothermic, the fermenter get heated and no temperature control is needed. The fermentation is carried out for 50 hours at 30 to 40^{o}C in fermenter, after mixing yeast starter and medium.

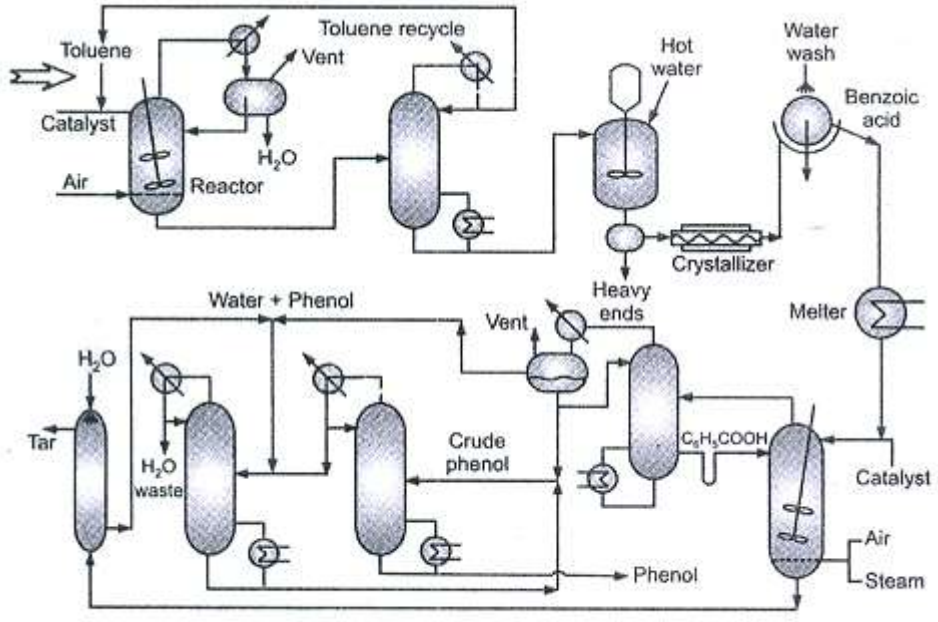
v. **Recovery** : The fermented mesh (beer) is distilled to obtain pure ethyl alcohol. The fractions containing 60% alcohol are known as high wine. These fractions are then distilled to get 95% alcohol (raw spirit). Because of the lability of alcohol to form an azeotropic mixture containing 5% water ever after successive distillation only 95% alcohol is obtained.

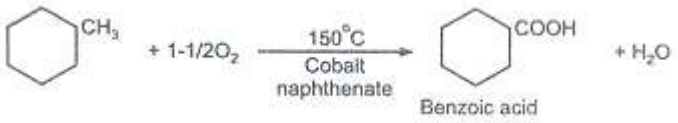
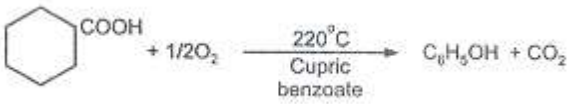
To prepare absolute ethanol, the 5% water is removed by forming aazeotropic mixture of benzene, water and ethanol which is then distilled with increasing temperature.

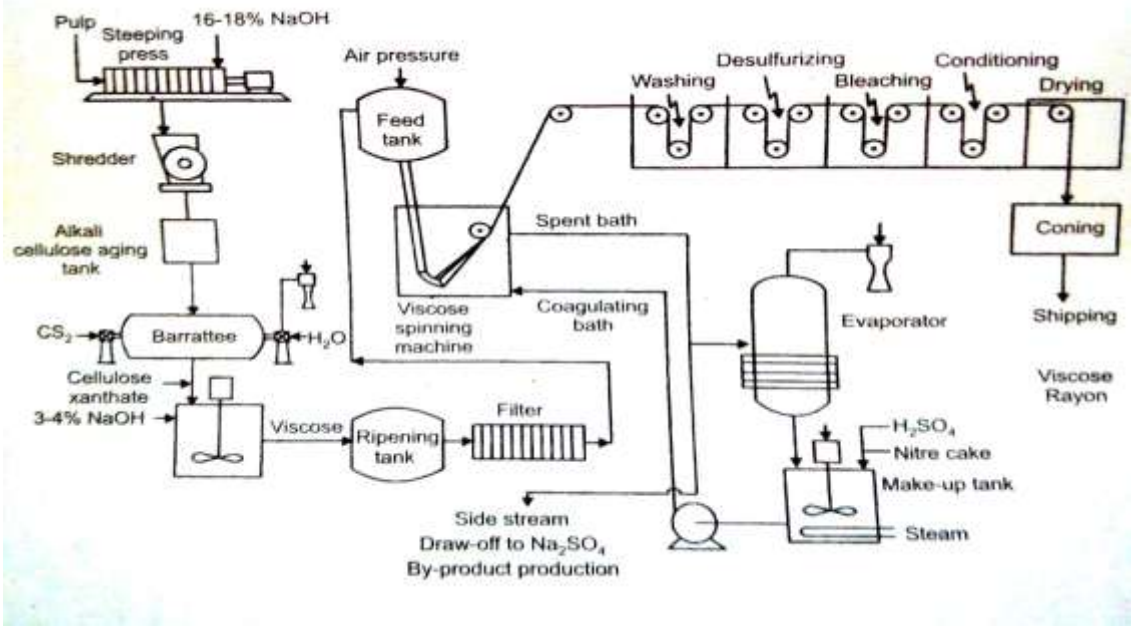


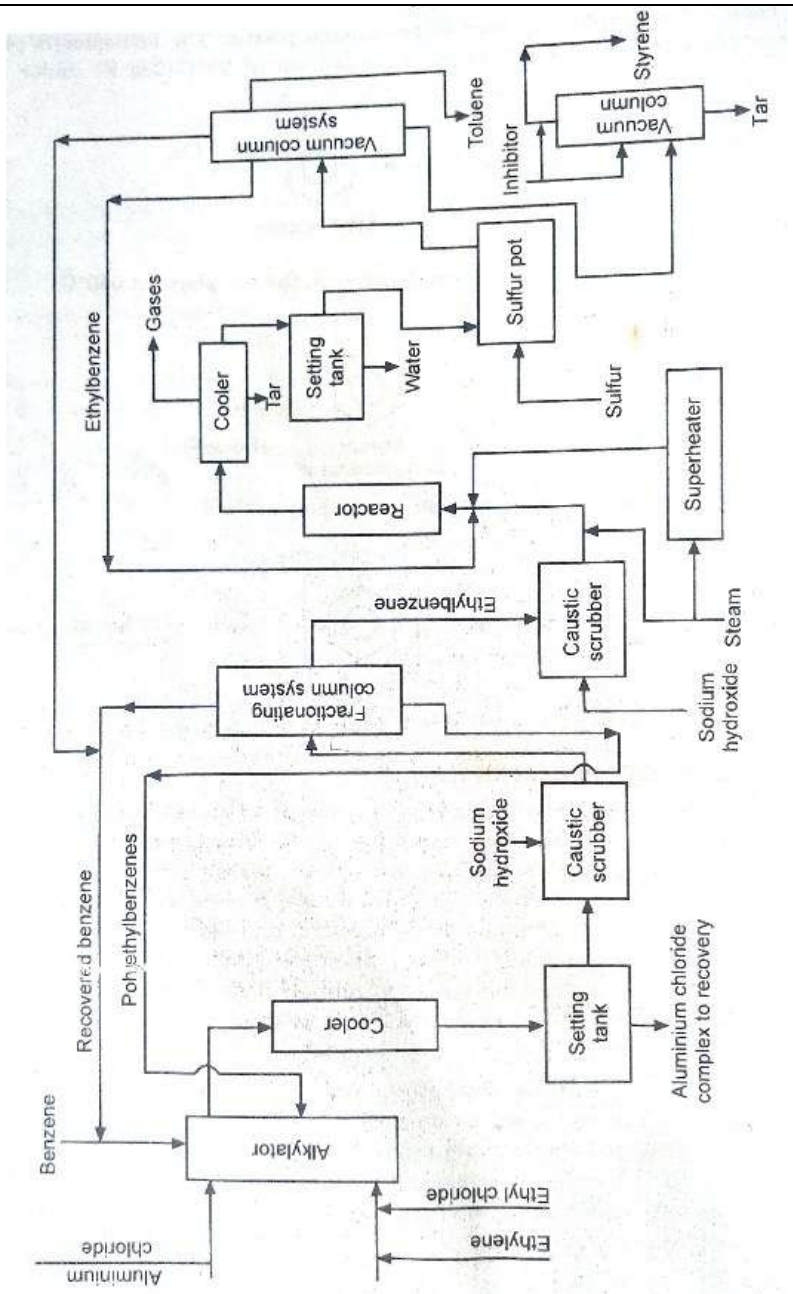
4

	b)	**Detergent Constituents** **Detergent Builder** Detergent builders are chemical compounds that are added to a detergent product to improve its cleaning properties. In this broad definition, cleaning is measured by the net amount of soil removed; that is, the total soil removed, less the amount that is redeposited. Thus only those materials are considered to be builders that perform both functions: (1) increasing the removal of soil and (2) preventing or minimizing its redeposition. These overall functions of detergent builders in turn result from a combination of several individual effects: Removing or sequestrating Ca2+ and Mg2+ ions from both the wash water and the soiled wash load Providing an alkaline environment Enhancing surfactant performance Desorbing soil (from the wash load) and stabilizing its dispersion in the wash liquor.	2
		Additives Additives in detergent are used to enhance the function of detergent like inhibiters, tarnish inhibiters. Perfumes and pigments are also used to increase its cleaning power and salability. Corrosion inhibiters like sodium silicate protect metal and washer parts from action of detergent and water. Carboxy methyl cellulose is used to prevent redisposition of soil on cloths.	2
		Bleaching Agent A bleaching agent is a material that lightens or whitens a substrate through chemical reaction. The bleaching reactions usually involve oxidative or reductive processes that degrade color systems. These processes may involve the destruction or modification of chromophoric groups in the substrate as well as the degradation of color bodies into smaller, more soluble units that are more easily removed in the bleaching process. The most common bleaching agents generally fall into two categories: chlorine and its related	2

		compounds (such as sodium hypochlorite) and the peroxygen bleaching agents, such as hydrogen peroxide and sodium perborate. Reducing bleaches represent another category. Enzymes are a new category of bleaching agents. **Brighteners** Brighteners an integral part of all washing powders, optical brighteners are dyestuffs absorbed by textile fibres from solution but not subsequently removed in rinsing. They convert invisible ultraviolet light into visible light on the blue side of the spectrum, causing the fibre to reflect a greater proportion of visible light and making it appear brighter. Optical brighteners are synthetic chemicals added to liquid and powder laundry detergents to make clothing appear whiter and brighter, and thus cleaner. They are the modern day replacement for the decades-old practice of bluing—adding small amounts of blue dye to fabric to make it appear whiter.	2
	c)	**PFD- Phenol manufacturing by toluene oxidation**  Flow sheet for manufacturing of Phenol from Toluene oxidation	4

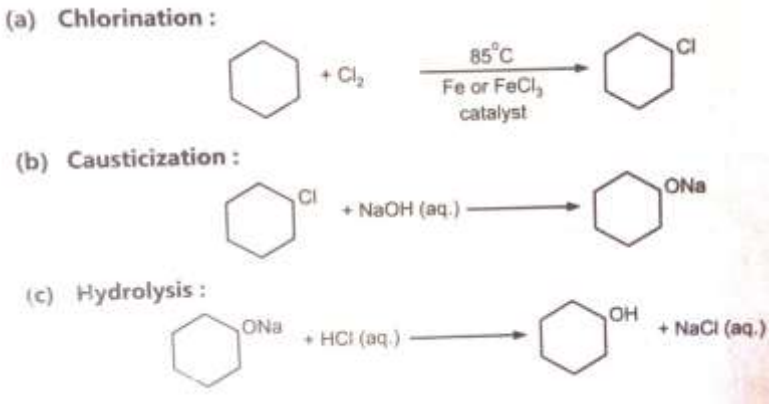
		Phenol production from toluene **(a) Oxidation to benzoic acid :**  **(b) Oxidation of benzoic acid to phenol :**  	4
6		**Attempt any two**	**16**
	a)	**Manufacturing of Viscos Rayon** **Process** Viscose rayon is a fiber of regenerated cellulose; it is structurally similar to cotton but may be produced from a variety of plants such as soy, bamboo, and sugar cane. To prepare viscose, dissolving pulp is treated with aqueous sodium hydroxide (typically 16-19% w/w) to form "alkali cellulose," which has the approximate formula [C6H9O4-ONa]n. The alkali cellulose is then treated with carbon disulfide to form sodium cellulose xanthate. The higher the ratio of cellulose to combined sulfur, the lower the solubility of the cellulose xanthate. The xanthate is dissolved in aqueous sodium hydroxide (typically 2-5% w/w) and allowed to depolymerize to a desired extent, indicated by the solution's viscosity. The rate of depolymerization (ripening or maturing) depends on temperature and is affected by the presence of various inorganic and organic additives, such as metal oxides and hydroxides. Air also affects the ripening process since oxygen causes depolymerization. Rayon fiber is produced from the ripened solutions by treatment with a mineral acid, such as sulfuric acid. In this step, the xanthate groups are hydrolyzed to regenerate cellulose and release dithiocarbonic acid that later decomposes to carbon disulfide and water: Aside from regenerated cellulose, acidification gives hydrogen sulfide, sulfur, and carbon disulfide. The thread made from the regenerated cellulose is washed to remove residual acid. The sulfur is then removed by the addition of sodium sulfide solution and impurities	4

		are oxidized by bleaching with sodium hypochlorite solution.  	4
	b)	**PFD of Polystyrene**	8

			
	c)	**Phenol from chlorobenzene-Caustic process** Dry benzene and catalyst of iron turning are charged continuously into a chlorinator. The partially chlorinated mixture boils up into a fractionating column. Benzene is fractionated from the top and returns as cycle recycle while mono chloro benzene is withdrawn near the bottom plate of the column.	2

Chlorobenzene and dilute caustic soda (10% solution) are mixed in a pump in a mole ratio of 1:1.25 . Diphenyl oxide is added to repress the formation of more diphenyl oxide and mixture is pumped through a preheater, then to multi tube reactor where causticisation occurs at 425°C and 350 atm. Residence time is around 15 minutes. Heat is removed from reactor reflux by exchange in the feed pre heater. The cooled hydrozylate is acidified in neutralizer to liberate phenol and sodium chloride which must be separated by distillation.

Reaction



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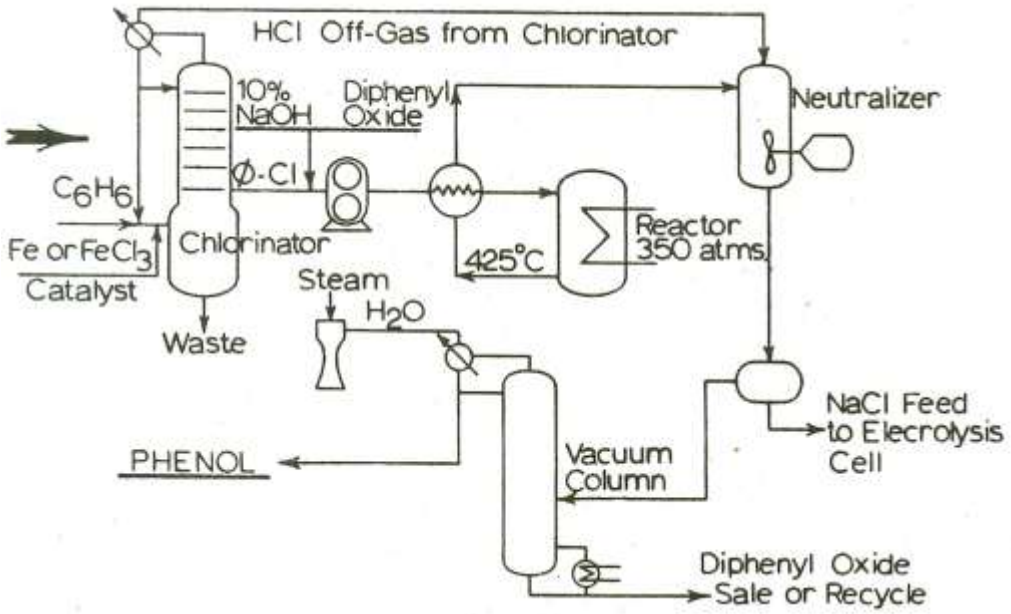
PFD



4