SUMMER-19 EXAMINATION

Model Answer

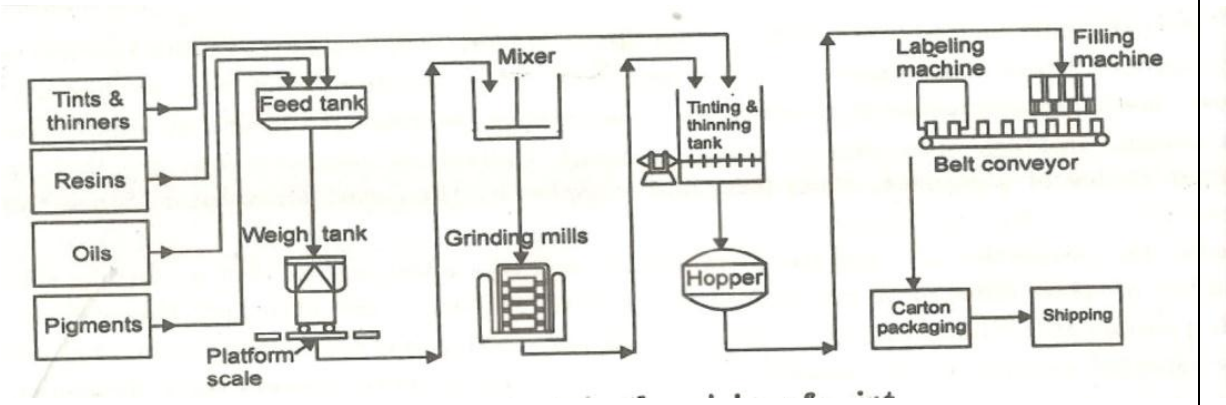
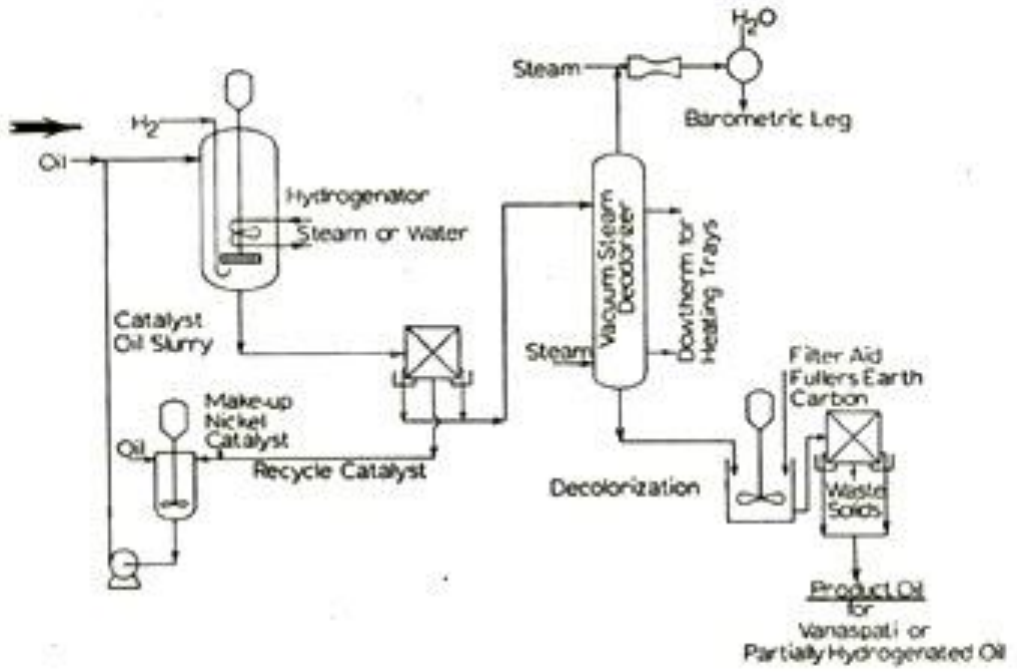
Subject Name: Chemical Process Technology-2 **Subject Code:** 17427

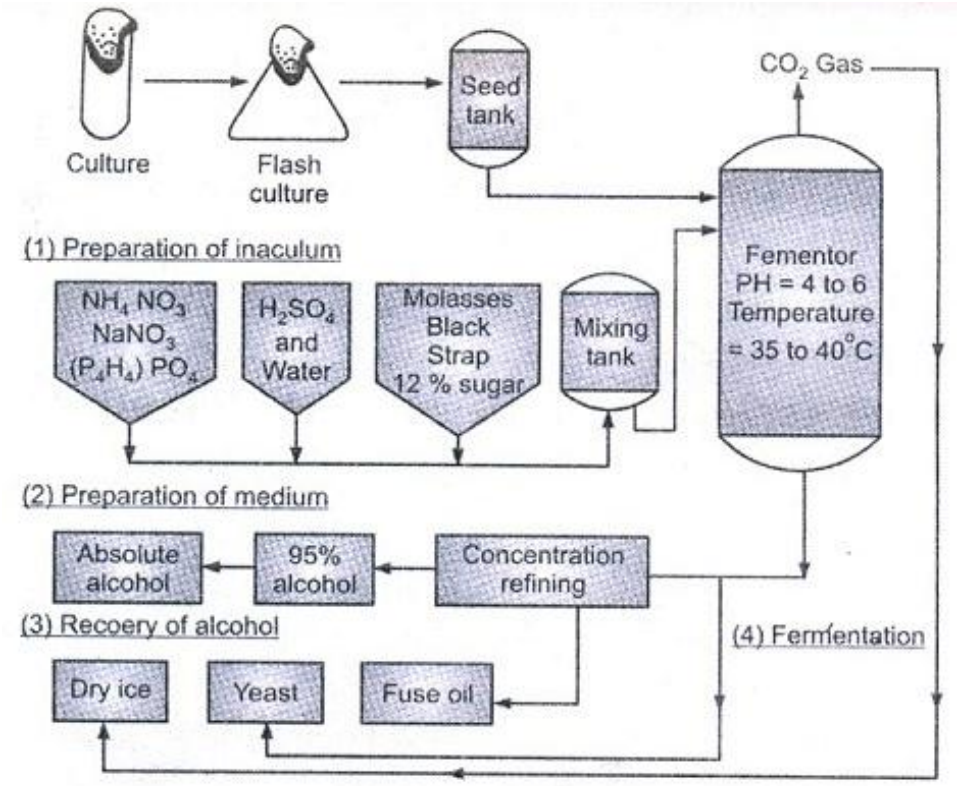
Important Instructions to examiners:

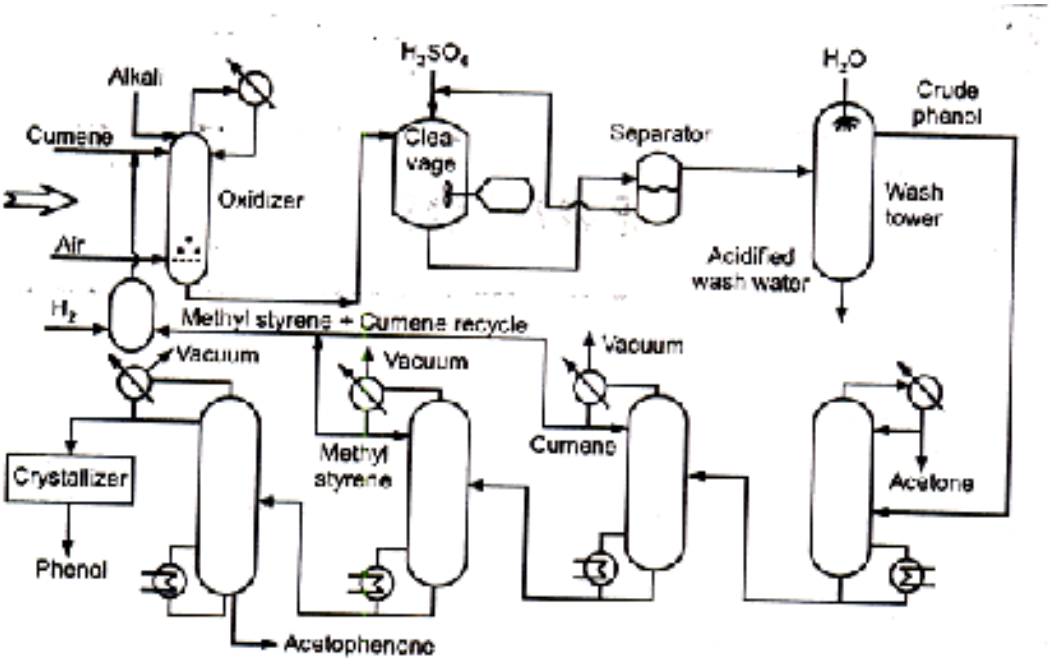
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

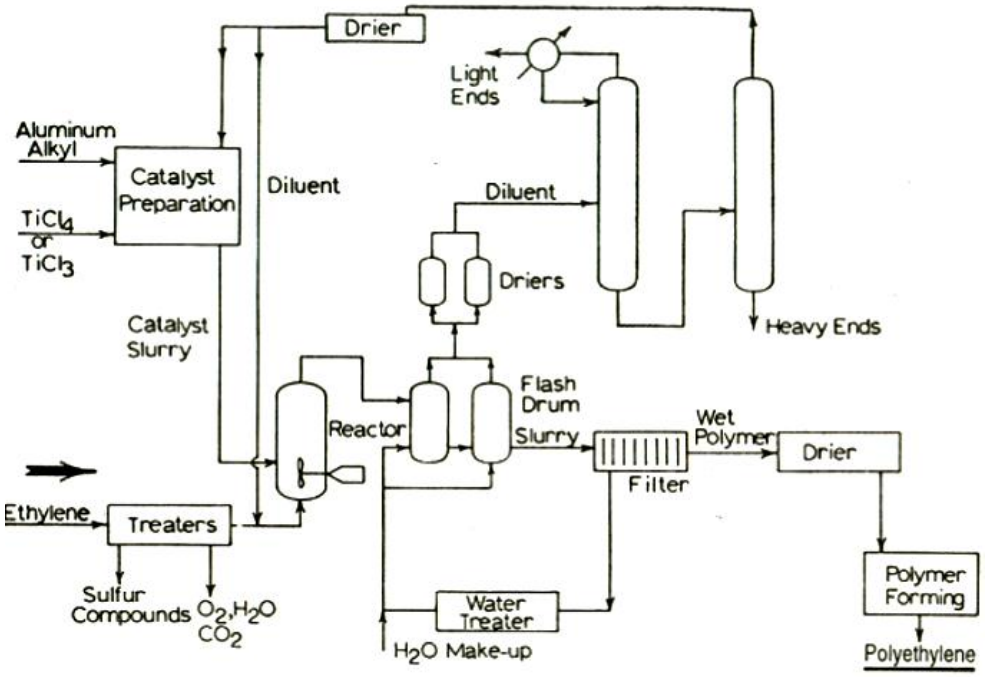
Q. No.	Sub Q. N.	Answer	Marking Scheme
1	**A**	**Attempt any SIX**	**12**
	a)	**Types of Papers** Printing Paper:- To use in office printing ,Xeroxing Wrapping Paper:- To make bags, cartoon wrapping Book paper:- To make text books, handbooks Tissue Paper:- to make cigarette, toilet paper, napkin papers Groundwood printing paper:- To make catalogue, newsprint, poster Paperboard:- boxes, cartoons	1 mark each for any two
	b)	**Saponification value** It is the no. of milligrams of KOH required to saponify one gram of an oil or fat.	2
	c)	**Vinegar** is a liquid consisting of about 5–20% acetic acid (CH_3COOH), water, and other trace chemicals, which may include flavorings. It is used as a cooking ingredient, or in pickling. It is also used for medicinal purpose, antimicrobial, cleansing agent.	2
	d)	**Fermentation:** The chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat.	1

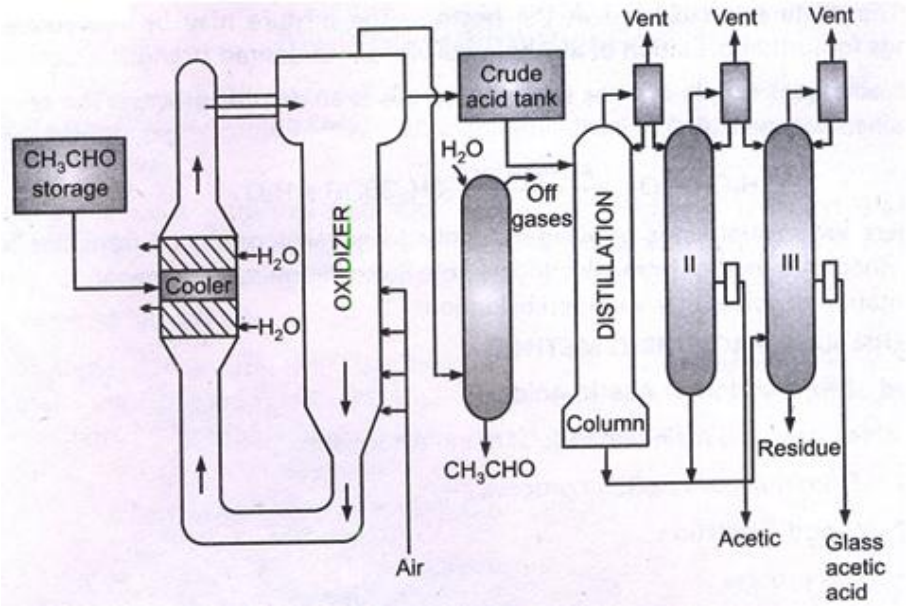
		Example Production of alcohol Production of antibiotics and drugs In sewage treatment Agricultural feed	1
	e)	**Sources of cellulose Pulp** • Babmoo • Agricultural residue • Bagasse, • Cereal straw • Reeds • Esparto grass • Jute • Flax • Sisal • Softwood (spruce, pine, fir, larch, aspen, eucalyptus)	1 mark each for any two
	f)	**Iodine value** Iodine value is the no. Of grams of iodine absorbed by 100 grams of oil or fat for its complete saturation. **Acid Value** The Acid Value is the number of milligrams of potassium hydroxide (KOH) necessary to neutralize the fatty acids in 1 gram of sample.	1 1
	g)	**Enzymes used in manufacture of alcohol** • Invertase • Zymase	2
	h	**Soap** Soap is sodium or potassium salt of fatty acid which can be used as cleansing agent.	2
	B	**Attempt any TWO**	**8**

	a)	**Application of** **Polyester** Textile, fishing nets, filter cloth. Conveyor belt **Poly vinyl chloride** Pipes, raincoats, cables, vinyl flooring	2 marks for each use
	b)	**PFD for manufacturing of paint** 	4
	c)	**PFD hydrogenation of oil** 	4

2		Attempt any FOUR	16
	a)	**PFD of alcohol from molasses**  	4
	b)	**Types of varnishes** i) Oil varnishes ii) Spirit varnishes **Uses** i) For protection of articles against corrosion ii) As a brightening coat to the painted surface iii) For improving the appearance and intensifying ornamental grains of wood surfaces,	2 2
	c)	**Raw material for Paper** • Cellulose from banboo, bagasse or wood etc • Cooking liquor (lime + Na_2SO_4) • Additives	2

		Additives for improving quality of Paper China clay Alkyl ketene dimer Epichloriohydrine Malamine Carboxymethyl cellulose Calcium carbonate	2
	d)	**Manufacturing of Phenol from Cumene** 	4
	e)	**Ziegler process for the manufacturing of polyethylene**	4

			
	f)	**By products of oil manufacturing** 1. Oil seed cake :- As animal feed pr low grade fetilser 2. Lecithin :- animal feed, chocolate, cosmetics 3. Free Fatty Acid from refining :- Soap manufacturing, medicine 4. Seed shells : As a fuel	4
3		**Attempt any FOUR**	**16**
	a)	**Manufacturing process of acetic acid from acetaldehyde** The continuous oxidation of CH_3CHO in liquid phase is generally carried out by using air or oxygen in presence of manganous acetate. The reaction mixture containing CH_3CHO diluted with crude acid and manganous acetate solution is circulated upward through oxidation tower. Reaction condition when air is used, 55 – 65 0C and 5 atm pressure and when oxygen is used then temperature 70 – 80 0C and pressure sufficient to keep the acetaldehyde in liquid state. The reaction mixture 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 other volatile components are withdrawn as overhead and residue containing manganous acetate is removed at the bottom.	2

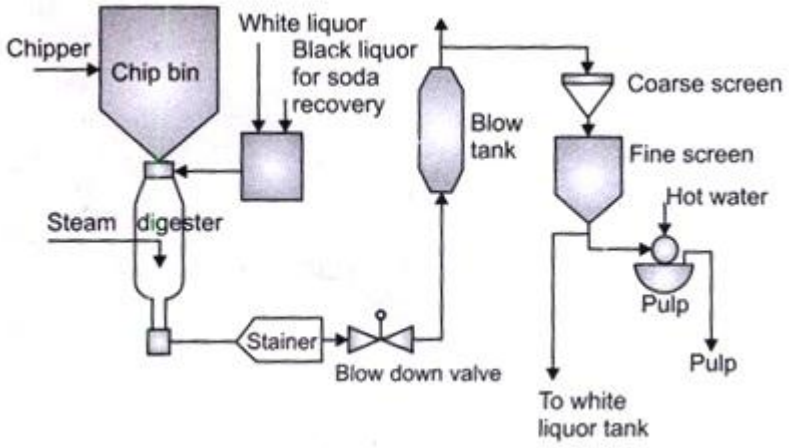


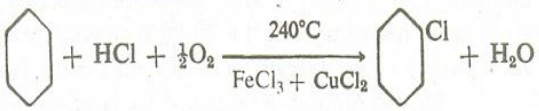
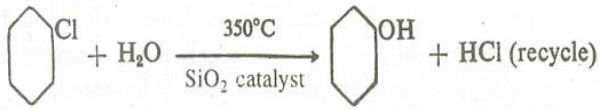
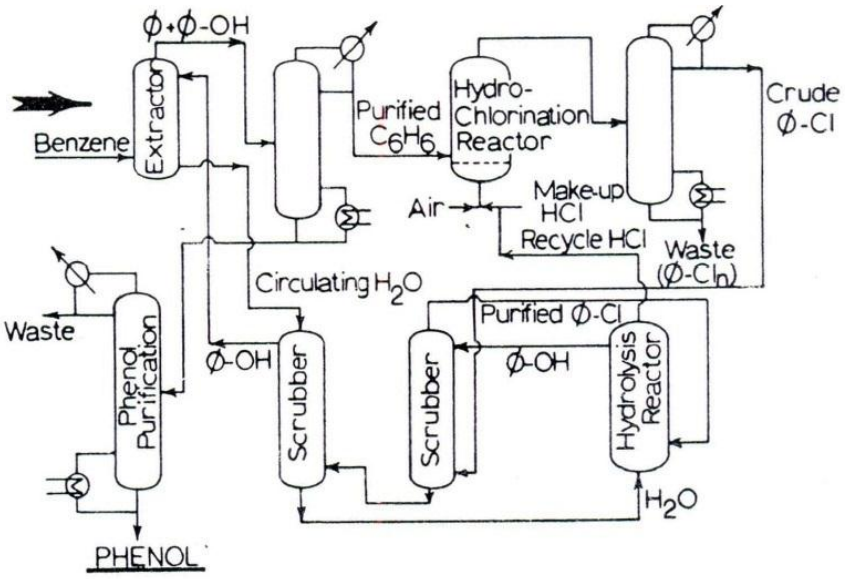
2

b) **Difference between varnish and lacquer** — 1 mark each for four differences

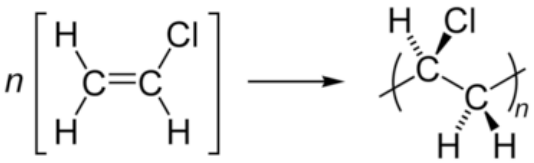
Varnish	Lacquer
Varnish is a homogenous colloidal dispersion solution of resin in oils or thinner or both.	Lacquers are dispersion of cellulose or other cellulose derivatives, resins and plasticizers in solvents
Solvent used-Oil	Solvent used – Ether, alcohol, ketones
Manufacturing- Cooking	Manufacturing - Mixing
Mode of drying – Oxidation polymerisation	Mode of drying - Evaporation

c) **PFD of craft process** — 4

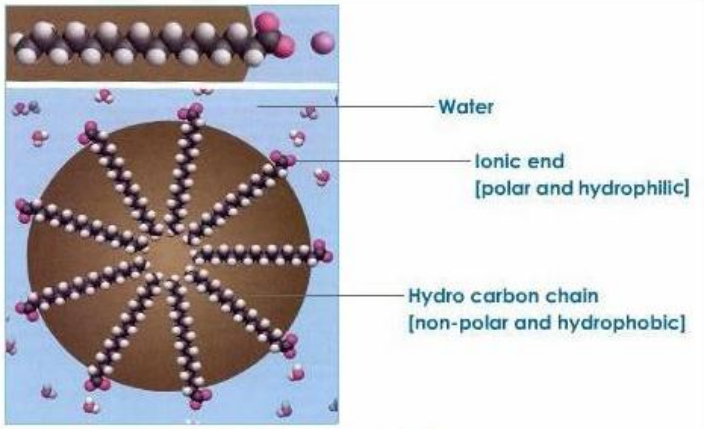


	d)	**Manufacturing of Phenol by Raschig process** Chemical reactions (a) Hydrochlorination  (b) Hydrolysis  Process description: the Raschig process has two vapour-phase catalyst stages. Purified benzene is fed to a heater, packed reactor containing ferric chloride & cupric chloride catalyst. Chlorination with HCl-O_2 at 220^0C 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  	2 2

	e)	**Manufacturing of Polystyrene** **Raw material** Benzene and ethylene **Reactions** $C_6H_6 + H_2C=CH_2 \rightarrow C_6H_5CH_2CH_3$ $C_6H_5CH_2CH_3 \rightarrow C_6H_5CH=CH_2 + H_2$ $C_6H_5CH=CH_2$ Benzene is alkylated with ethylene in the presence of an aluminium chloride or boron trifluoride catalyst. Dry benzene (99%) and ethylene (95%)are continuously fed into an alkylating tower operating at an essentially atmospheric pressure. Small amount of ethyl chloride is added as a catalyst promoter. Granulated AlCl3 is used as a catalyst. About 75 to 100 kg of ethylbenzene can be obtained per kilogram of aluminium chloride catalyst. The reaction temperature is maintained at 95 0C. The crude ethylbenzene from the settling tanks is washed with 50% caustic solution to neutralize it. The crude alkylate contains 36% to 42% ethylbenzene, 40% to 55% benzene and 10% 20% polybenzene. By removing other impurities, ethylbenzene is purified. Purified ethylbenzene is heated with steam and ethylbenzene vapours. Sulphur and heated steam (720 0C) are continuously mixed in reactor. Catalysts such as zinc, chromium, iron on activated charcoal is used. Crude styrene contains 37% styrene and 61% ethyl benzene. It is passed through a pot containing sulphur. Under vacuum, other impurities are removed. Ethyl benzene is also removed at 90 0C and under vacuum. Finally pure styrene is obtained by distilling it under vacuum and by adding polymerization inhibitors. Styrene thus obtained can be polymerized to obtain polystyrene.	2 2
	f)	**Manufacturing of PVC** Reaction $C_2H_2 + HCl \rightarrow CH_2=CHCl$ OR $CH_2=CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$ $CH_2ClCH_2Cl \rightarrow CH_2=CHCl + HCl$	2

		Vinyl chloride monomer can be polymerized to produce PVC  The reactivity of vinyl chloride, $H_2C=CHCl$ is due to the carbon-carbon double bond. It undergoes rapid polymerization when exposed to high energy radiation or when peroxides are added. The polymerization is a exothermic reaction. The chain grow by repeated head-to-tail addition reaction of the monomers. The monomer molecules arrange themselves in the order front-back-front-back as the position of the chlorine atoms in the thread like molecule shown reaction. A head-to-head addition reaction is a rare and exceptional event with PVC. Polyvinyl chloride is a white solid. It is usually fabricated in the form of powder.	2
4		**Attempt any FOUR**	**16**
	a)	**Types of paint:** **1) Decorative and building paints** Application- Flat wall paint, interior, Floor paints, heat and fire resisting **2) Industrial and marine paints** Application- ship paints, anti-fouling paints, urethane oils	2 2
	b)	**Polymer:** Polymer is composed of large number of molecules called as monomers. **Initiator:** A chemical species which react with monomers to form an intermediate compound capable of linking successively with the large number of other monomers in to a polymer. **Types of Initiator:** Free radical forming, acid forming, ionic initiator.	1 2 1
	c)	**Raw materials for butanol** Propylene , Hydrogen, Synthesis gas **Reaction**	4

		(a) Aldehyde step $C_3H_6 + CO + H_2 \rightarrow CH_3 \cdot CH_2 \cdot CH_2 \cdot CHO$ / $(CH_3)_2CH \cdot CHO$ (b) Alcohol step $C_3H_7CHO + H_2 \xrightarrow[150°C \\ 100 \text{ atms.}]{\text{Ni catalyst}} C_3H_7CH_2OH$ **Process description:** Propylene is compressed at 150 atm and cobalt napthanate added to give 0.5 to 1 % CO in sol. This stream is passed concurrently with CO+H_2 stream through a packed bed tower The tower contains a porous carrier with 2 % metallic cobalt deposited The reaction is highly exothermic and temperature of 170 deg C is controlled by recycle of a portion of prod stream after cooling The product liquid fraction is mixed with steam at 180 deg C and a relatively low pressure of 20 atm. To decompose cobalt carbonyl and napthanate depositing cobalt on porous carrier as oxides This cobalt is dissolved periodically in an acid wash and converted in napthanate for reuse Crude butaraldehyde from demerisation reactor is continuously hydrogenated using a fixed bed nickel catalyst at 100 atm and 150 degC The resulting butanol are fed to a distillation column comprising of several fractionating column in series Light and heavy ends are obtained in addition to the product alcohol.	
	d)	**Cleansing action of soap** The dirt on skin or cloth sticks due to greasy matter. When rubbed with soap solution, it is easily washed away. Soap molecule has a polar end (-COO-Na+) and a non polar end (a long carbon chain of 12 to 18 carbons). The polar end is water soluble while the non polar end is oil soluble. Normally oil droplets in contact with water tend to coalesce to form oil layer and aqueous layer. The non polar ends of soap molecules dissolve in the oil droplet leaving the carboxyl ate ends projecting into the surrounding water. Due to the presence of negatively charged carboxylic groups, each of the oil droplets 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.	4



e) **Comparison between soap and detergents.** — 1 mark each for four differences

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.

f) **Raw material for mfg. of rayon-** — 3

The wood cellulose, caustic soda, carbon di-sulphide aqueous solution of H_2SO_4

Reaction

$$[C_6H_7O_2(OH)_3]_n + nNaOH \rightarrow [C_6H_7O_2(OH)_3NaOH]_n$$

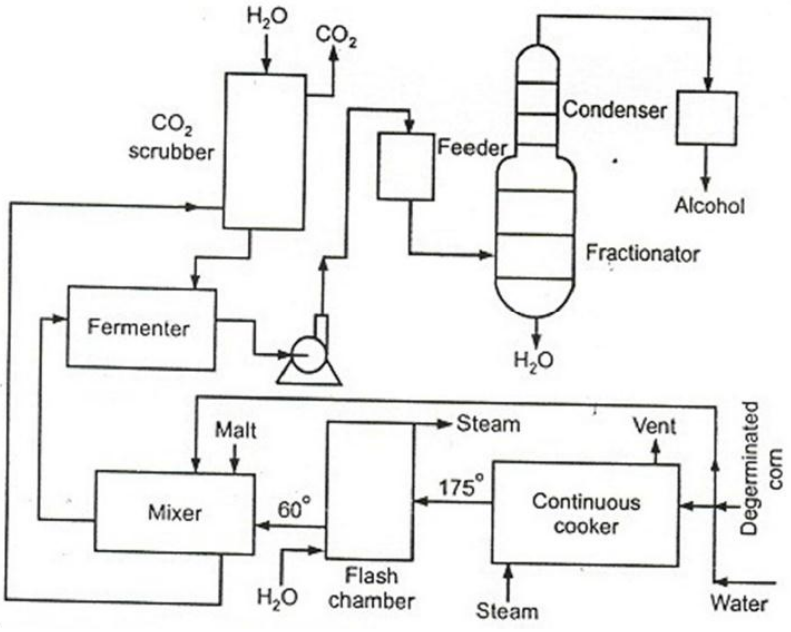
Cellulose alkali Alkali cellulose

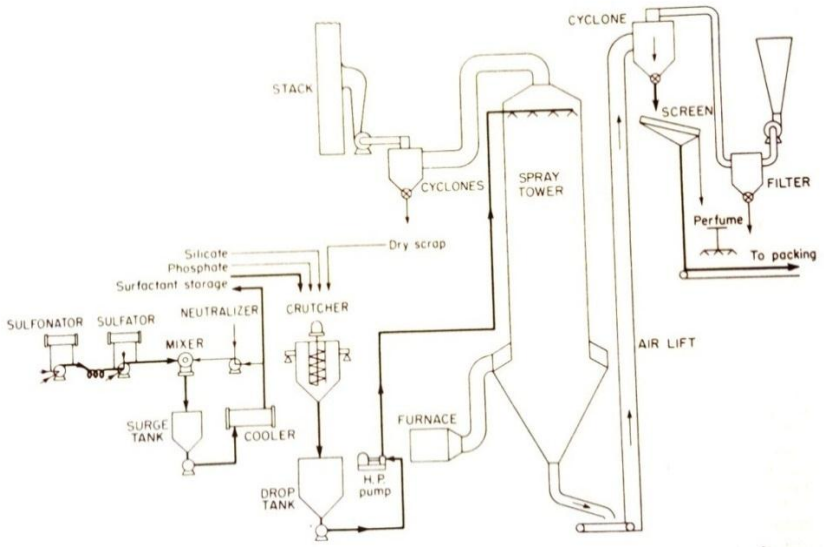
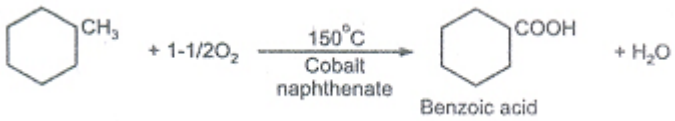
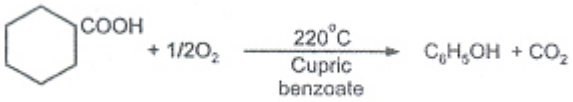
$$[C_6H_7O_2(OH)_3NaOH]_n + nCS_2 \rightarrow \left(\begin{array}{l} OC_6H_9O_4 \\ C{=}S \\ SNa \end{array}\right)_n + nH_2O$$

$$\left(\begin{array}{l} OC_6H_9O_4 \\ C{=}S + nH_2O \\ SNa \end{array}\right)_n + nH_2SO_4 \rightarrow [C_6H_{10}O_5]_n + nCS_2 + nNaHSO_4$$

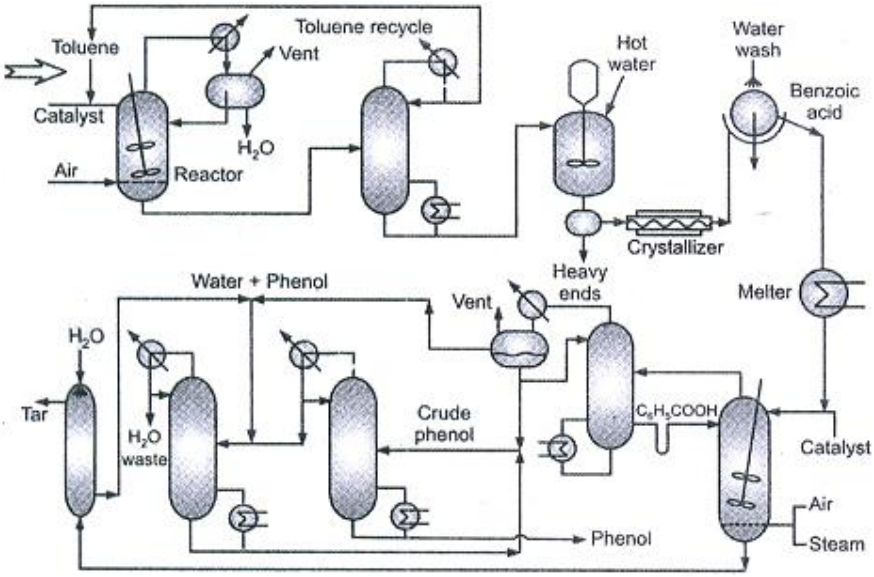
Viscose fibre

		Uses of Rayon 1. Tire chord 2. Artificial hair 3. Bottle plugs 4. Fibers 5. Cellophane	1
5		**Attempt any TWO**	**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 $C_6H_{12}O_6 \xrightarrow{Zymase} C_2H_5OH + 2\,CO_2$ The corn is fed to cooker, cooker is necessary to gelatinize the ground grain so that the barley malt amylase can convert the starch to fermentable sugars. The cooker may be batch or continuous and are operated under pressure. In continuous process grain is precooked for 1 to 5 min with water. The mass is continuously fed to steam heater that instantaneously raises temperature to 175deg C. The mass is passed through series of pipes and discharged through a relief valve into flash chamber. Time in cooker is about1.5 min and pressure is maintained at 60 to 100 gauge. The temperature of mass drops to about 60 deg C in flash chamber. The coked grain mass is missed with malted barley and water and this is send to fermentator. The gases during fermentation are scrubbed by using water and send to series of rectification column and the condensation product is nothing but alcohol.	2 2

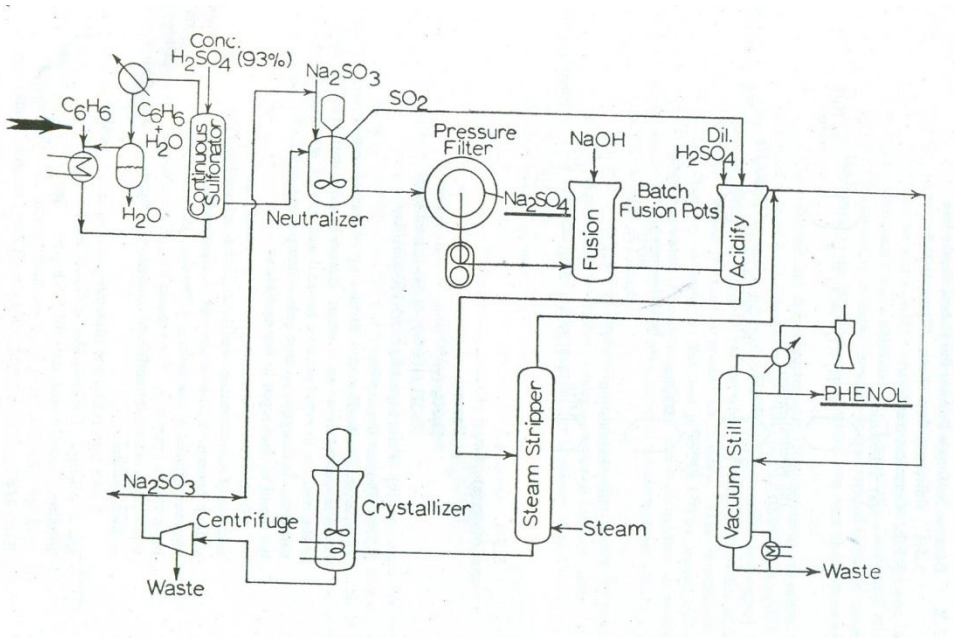
			4
	b)	**Manufacturing of detergent from fatty alcohol** The alkyl benzene is introduced continuously into sulfonator with the requisite amount of oleum, using the dominant batch principle. To control the heat of sulphonation conversion and maintain the temperature at about 55^{o}C. Into the sulfonation 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.	5

			3
	c)	**Phenol by toluene oxidation** **(a) Oxidation to benzoic acid :**  **(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 CO_2.With conversion of toluene at 40% the ultimate yield of benzoic acid is about 90%. Off-gases	2 2

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 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^{o}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.



2

		Uses of phenol for production of • Phenol formaldehyde • epoxy resins • herbicides, • insecticide • In pharmaceutical industry	2
6		**Attempt any TWO**	**16**
	a)	**PFD of Phenol by benzene sulphonate process**  	8
	b)	**Production of paper from pulp** Conversion of fibre suspension into paper sheet incorporates three principal steps. i) **Forming wet-web** : A wet sheet is formed by running 99.5% water-fibre slurry evenly into a moving endless belt of wire cloth at speed of 50 m/min for a fine paper to 500 m/min for newsprint. Water drain by gravity , apart is next removed by a pressure roll and then by suction roll. The	4

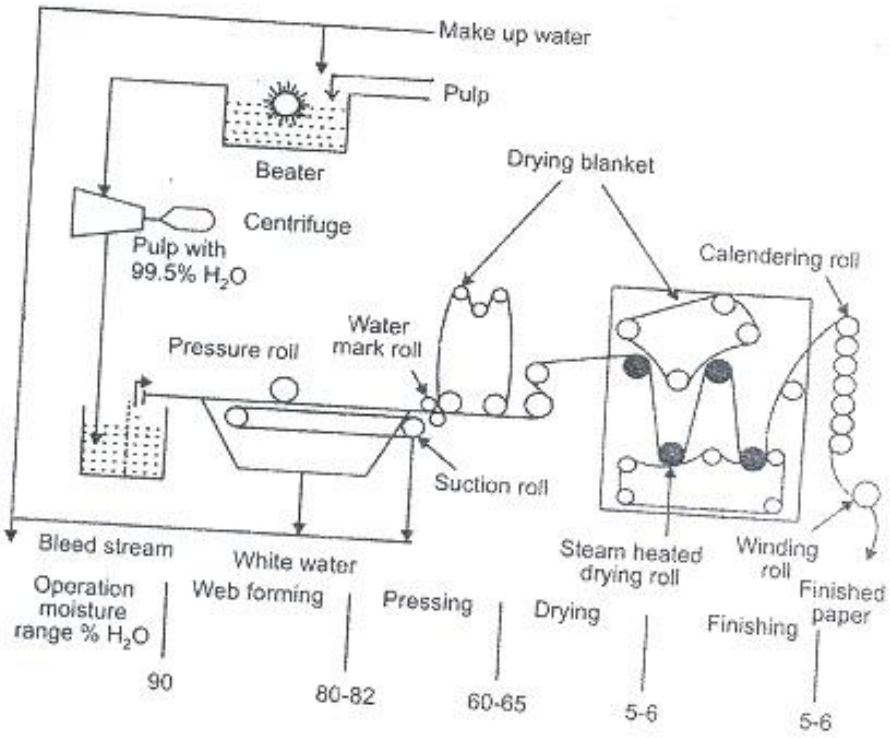
screen also has a side wise shaking motion to give better interlocking of fibre on the mat. The water collected in this section of machine is called white water and is reused to obtain maximum recovery of fibre.

ii) **Pressing the wet sheet** :

The wet paper wheet containing about 80% water is fed via felt roll to the press section where water is removed by mild pressure to reduce content to 60-65% water. Bond or water mark, if needed is formed on sheet during pressing.

iii) **Drying of sheet** :

The sheet from the press section has sufficient strength to carry its own weight as it passed through smoothing rolls, then a series of steam heated metal cylinders where heat and moisture are transferred to a felting or canvas belt running on top of the paper. As the sheet leaves the east drying roll with 5-6% water, it passes through final series of pressure or calendaring rolls to produce a smooth well-finished paper. It is wound on large roll and transferred to finishing department where it may be cut, coated and packaged.



4

c) **Comparison between addition and Condensation polymerization** 2 marks

		Addition polymerization	**Condensation polymerization**	each for four points
		In this the monomer molecules simply add together to form chains under suitable conditions of temperature and pressure and initiator	In this a new bond is formed between the monomers by elimination of small molecules like water under suitable conditions of temperature and pressure	
		This type of polymerization can only occur when monomer molecule is unsaturated	The reaction by which this polymerization takes place is condensation reaction	
		Polymers formed by addition polymerization are thermoplastics.	Condensation polymerization is used to form simple hydrocarbons	
		Ex. Polyethylene is produces by the addition polymerization of ethylene monomers.	ex. Production of phenol formaldehyde from phenol and formaldehyde monomers with condensation of water	