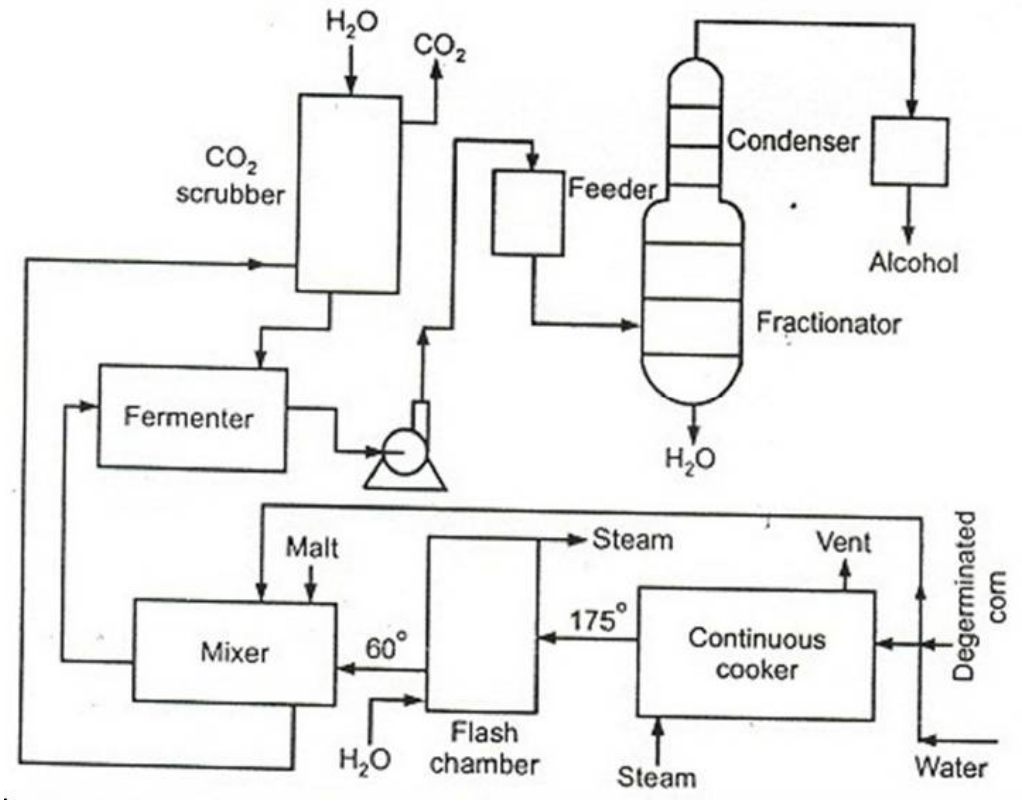
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q No.	Answer	Marks	Total marks
1 A a)	**Pulp** is a lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibers from wood, fiber crops or waste paper. Methods: Mechanical, Semi chemical, chemical (Sulphate and sulphite)	1 1	2
b)	**Uses of vegetable oil** Cooking For manufacturing of hydrogenated fats For manufacturing of soap For manufacturing of fatty acid In medicine For production of biodiesel In paint manufacturing	½ mark each for any four	2
c)	**Vinegar** It is food grade dilute acetic acid. **Uses** In food preparation In beverages In medicine As a cleaning agent	1 1	2
d)	**Enzymes used in alcohol manufacturing** Invertase zymase	2	2
e)	**Raw material for detergent** Fatty alcohol	1 mark each	2

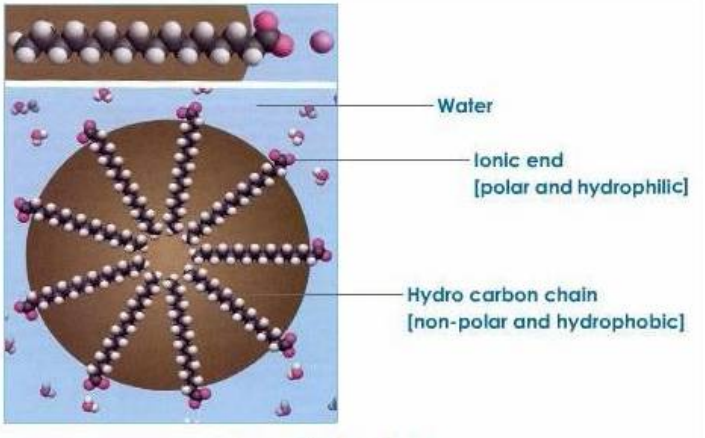
	Sulfuric acid Linear alkyl benzene sulphonate	for any 2	
f)	**Raw material for soap** Oil Caustic soda Sodium chloride	2	2
g)	**Uses of Rayon** Tire chord Artificial hair Bottle plugs Fibers Cellophane	½ mark each for any four	2
1 B a)	**Types of polymers** On the basis of manufacturing 1) Addition polymer eg. Polyethylene, polystyrene 2) Condensation polymer eg. Phenol formaldehyde On the basis of characteristics 1) Elastomers e.g synthetic rubber 2) Themosets e. g phenol formaldehyde, melamine formaldehyde, urea formaldehyde, epoxies 3) Thermoplastic e.g polyethylene, poly(vinyl chloride), polystyrene, nylon, cellulose acetate, acetal, polycarbonate, poly(methyl methacrylate), and polypropylene	2 2	4
b)	**Pigments** White : Titanium oxide or zinc oxide Black : Carbon black	1 mark each	4

	Blue : Ultramarine (sulfur-containing sodio-silicate) Red: Cadmium red(Cadmium selenide)		
c)	**Refined oil:** Edible oil which is decolorized, bleached, deodorized and free from FFA is called refined oil. Any refined cooking oil like soybean, palm, safflower, sunflower, mustered etc.	2 2	4
2 a)	**Manufacturing of alcohol from corn**  **Reaction** $2(C_6H_{10}O_5) + nH_2O = nC_{12}H_{22}O_{11}$ $C_{12}H_{22}O_{11} + H_2O = 2C_6H_{12}O_6$	3 1	4

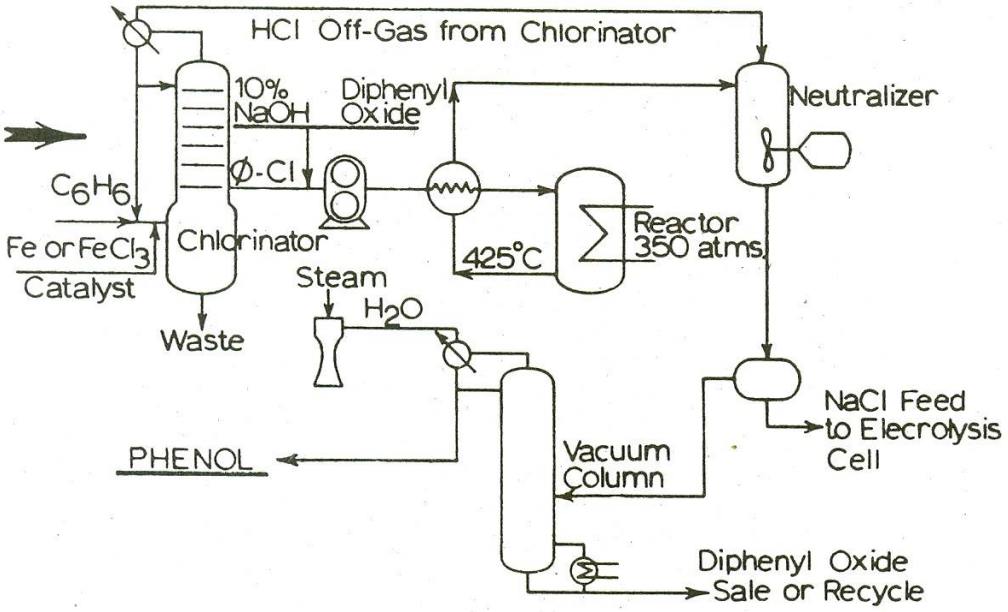
	$C_6H_{12}O_6 = C_2H_5OH + 2CO_2$		
b)	**Raw material of paint** **Pigments: -** It is finely divided solids generally made up metal oxides .It is used to give colour to paint. **Drying oil: -** These are unsaturated oils. It is used to form protective film and give gloss. **Thinners or solvent: -** It is alcohols or turpentine. is used to dissolve polymers in paint and to disperse pigments (emulsion formation).It adjust viscosity, form thin film. **Plasticizer: -** These are polymers. Used to impart elasticity to paint.	1 1 1 1	4
c)	**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 4	4
d)	**Phenol by toluene oxidation process** 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^oC 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	4	4

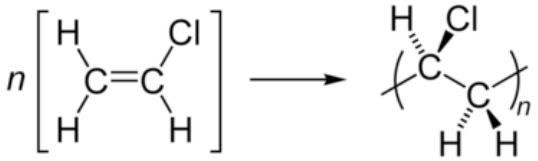
	about 90%. Off-gases from the reactor are vented through a water-cooled condenser to remove water and to allow return of toluene. Liquid from the reactor continuously passes to a distillation column which strips the toluene and other volatile by-products from the acid fraction in the bottoms. Purified benzoic acid is separated by extracting the bottoms with hot water, then 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.		
e)	**Uses** Polyethylene: Household utensils, packaging films, bottles, bucket, tubes, cable sheeting storage tanks etc.	1	4

	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	1 1 1	
f)	**Cleansing action of soap** Soap ions consist of two parts that is the head that consists of the anion region, ionic and also called the hydrophilic region which dissolves in water. Another part is the tail that consists of hydrocarbon region and its molecule has covalent characteristics. It's also called the hydrophobic region which dissolves in grease or oil(dirt) The soap molecules will dissolves in water and reduces the surface tension of water. Water wets the dirty surface. The hydrophilic region dissolves in water whereas the hydrophobic region dissolves in dirt such as grease. Grease is lifted off the surface of the material and suspended in water. The tail region emulsifies and breaks up the grease into small drops. When shaken, the water molecules will attract the soap ions and cause the grease to detach from the surface of the material. The soap bubbles help to float the grease emulsion in the water. When rinsed, the grease will be removed together with the water.	3 1	4

			
3 a)	**Ethyl alcohol :** Molasses is diluted to 10-15% sugar concentration and adjusted to pH of 4-5 is support to yeast growth which furnishes invertase & zymase catalytic enzymes. This diluted mixture called mash is run into a large wooden or steel fermentation tanks. Yeast solution grown by inoculating sterile mesh, is added and fermentation ensues with the evolution of heat which is removed via cooling coils. The temp. is kept 20-30 deg.C over a 30-70 hr. Period rising near the end to 35 deg.c Carbon dioxide may be utilized as a byproduct by water scrubbing. Separation of the 8-10% alcohol in the fermented liquor called beer is accomplished by serious of distillation columns. In the beer still 50-60% conc. and undesirable volatiles such as aldehyde are taken off the top and fed to the aldehyde still. Alcohol is pulled as a side stream split to the rectifying column. In this final column, the azeotropic alcohol water mix. of 95% ethanol is taken off as a side stream, condensed and run to storage where it is split into three parts. i) Direct sale ii)Denatured alcohol	4	4

	iii) Absolute alcohol		
b)	**Lacquers** are dispersion of cellulose or other cellulose derivatives, resins and plasticizers in solvents. **Applications** Decorative coatings for furniture &interior use Automobile finishes	2 2	4
c)	**Paper from pulp** 1)Preparation of fibre suspensions- Pulp is water slurried to 50-75% fibre content by mechanical disintegrations of various designs 2)Formation of paper i) Forming wet web: A wet sheet is formed by running 99.5% water fibre slurry. ii) Pressing the wet sheet: Water from wet sheet is removed by mild pressure to reduce content to 60-65% water. iii) Drying of sheet: A sheet from press section is passed through drying roll and then calendaring rolls to produce smooth well finished paper. Followings are various zones with moisture content i) Web forming-80-82% ii)Pressing- 60-65% iii) drying-5-6% iv) Finishing 5-6%	2 2	4
d)	**Phenol from chlorobenzene (PFD)**	4	4

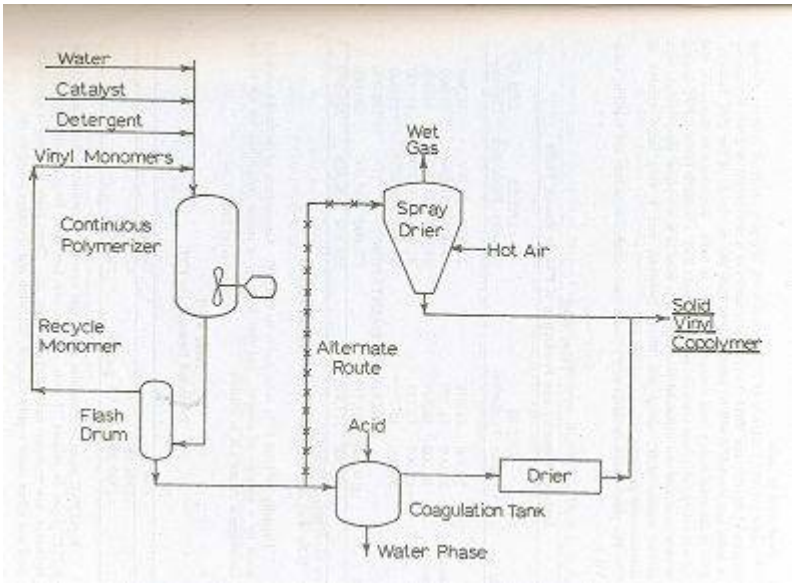
			
e)	**Uses of phenol** • Used in plastic industry for production of formaldehyde • Used as a herbicides, • insecticide • pharmaceuticals • Dyestuff.	1 mark each for any 4	4
f)	**Polyvinyl chloride** Reaction $C_2H_2 + HCl \rightarrow CH_2=CHCl$ OR $CH_2=CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$ $CH_2ClCH_2Cl \rightarrow CH_2=CHCl + HCl$ Vinyl chloride monomer can be polymerized to produce PVC	1	4



Raw Material 1
Vinyl chloride monomer (ethylene + chlorine)

In emulsion polymerisation,a typical formulation is100 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 directly. 1

1

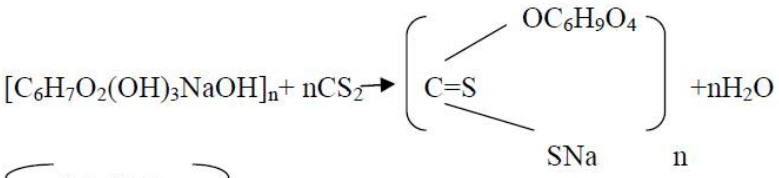
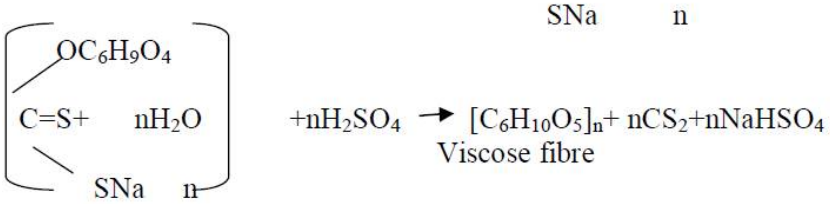


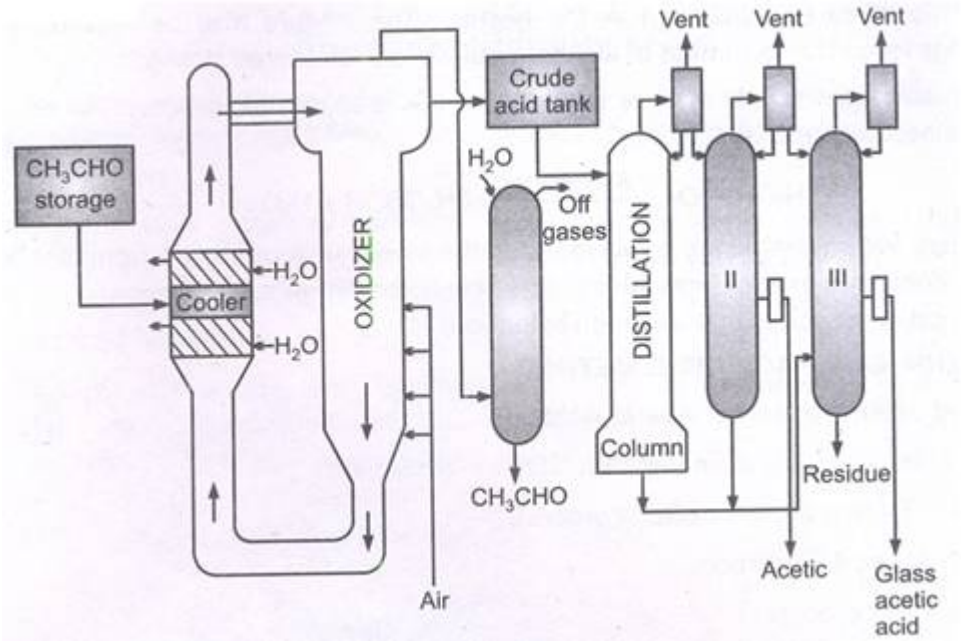
(block diagram drawn by student should be given marks)

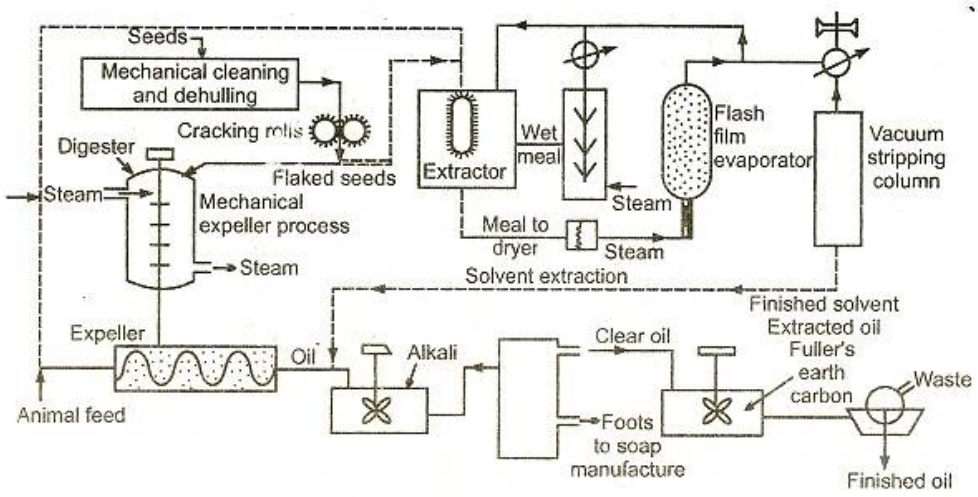
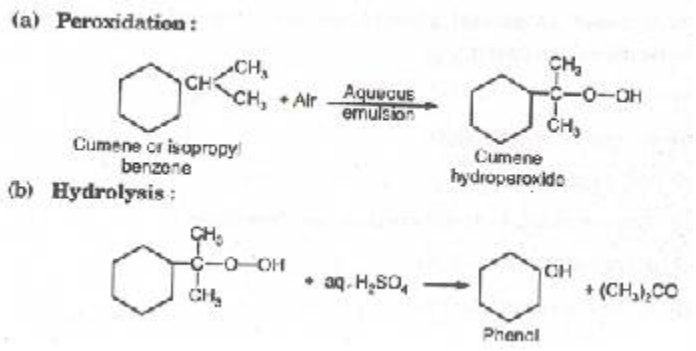
4 a)	**Polyethylene** In this type of process, small quantity of catalyst and solvent is charged to reactor and then ethylene feed is started. Ethylene, pressure is permitted to build upto 400-500 psi in less than 1 hr. At the end of reaction period, the polymer is removed, dissolved in additional solvent and filtered to remove catalyst. Polymer is recovered from filterate by cooling and hence solidification.	4	4
b)	**Use of extender** To reduce cost *Example* Talc, mica **Use of thinner** Dilutes the concentration and dissolves film forming material. *Example* Alcohol, naphthas, turpentine	2 2	4
c)	**Butanol** Propylene is compressed to 250 atms and cobalt naphthenate added to give 0.5-1% co in solution. This stream is passed co-currently through a packed tower containing 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. The liquid fraction is mixed with steam at 180 deg. C and a relatively low pressure of 20 atms. to decompose the cobalt carbonyl and naphthenate, depositing the cobalt on a porous carrier as the oxide. This cobalt is dissolved periodically in an acid wash and converted to naphthenate for reuse. The unconverted synthesis gas from the oxo converter is recompressed and	4	4

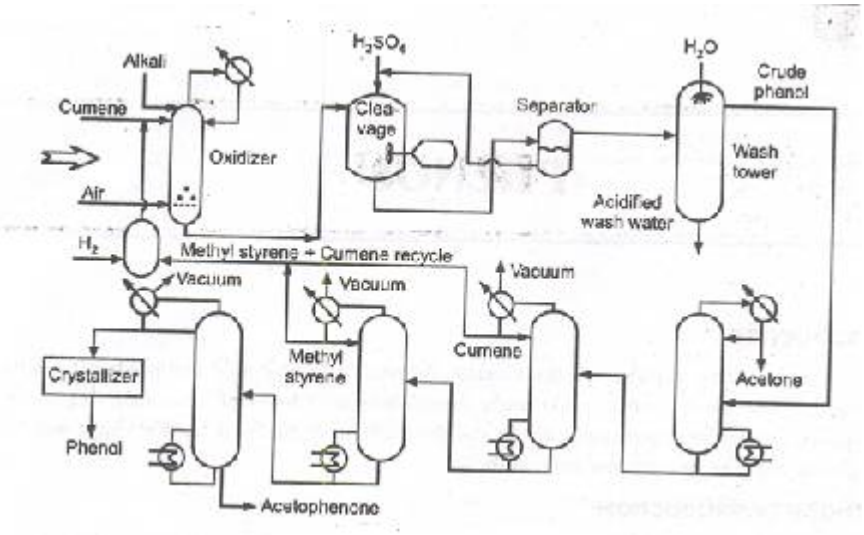
	recycled. The crude butyradehyde can be fractionated for product sales or continuously hydrogenated using a fixed bed Ni catalyst,100 atms,H_2 pressure, and 150 deg.C The resulting butanols are fed to distillation section comprising several fractionating column in series Light and heavy ends as by products are obtained in addition to the purified alcohol.		
d)	**Soap** Soap is defined as the sodium or potassium salts of long chain fatty acids. **Process description** Glycerides plus catalyst are added at the bottom of the hydrolysis tower where high pressure water at 230-250 deg.c is passed counter currently to the glycerides. Fat splitting reaction occurs with a 15-20 % glycerine solution being removed from the bottom of the tower. The fatty acids are passed overhead a flash tank to remove excess steam. The crude fatty acids are passed overhead to a flash tank to remove excess steam. The crude fatty acids are vacuum distilled and the condensate in the distillate receiver is either available as a marketable product or for soap manufacture. Caustic soda is added to fatty acids in a continuous high speed mixer and the saponification is completed in a slow speed blender where other ingredients are added if desired. Soap from the blender may be pumped through heated lines to soap flake or spray drying equipment followed by packaging operations.	1 3	4
e)	**Saponification value** It is the no. of milligrams of KOH required to saponify one gram of an oil or fat. *Importance*	2	4

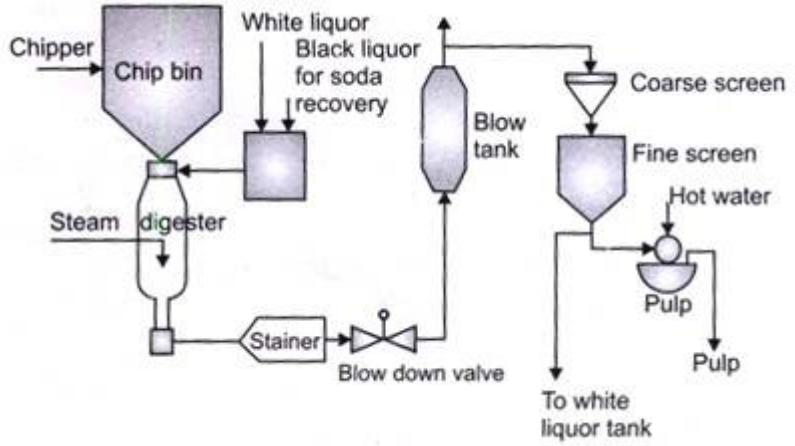
	i) Wheather an oil or fat contains lower or higher proportion of the same fatty acid. ii)The proportion of lower fatty acid or higher fatty acid in oil or fat. iii) From the saponification value , we know wheather oil is animal, vegetable or mineral iv) The saponification value gives the estimination of non fatty impurities. **Iodine value** Iodine value is the no. Of grams of iodine absorbed by 100 grams of oil or fat for its complete saturation. *Importance* i) Iodine value is the measure of unsaturation of oil or fat. ii) It helps in classification of oils. Thus, a) An oil containing one double bond has iodine value < 90---→ Non –drying oil. b) An oil containing two doubles has iodine value <140 -→ semi drying oil c) An containing three double bonds has iodine value > 140 --→ Drying oil.	2	
f)	**Rayon**	4	4

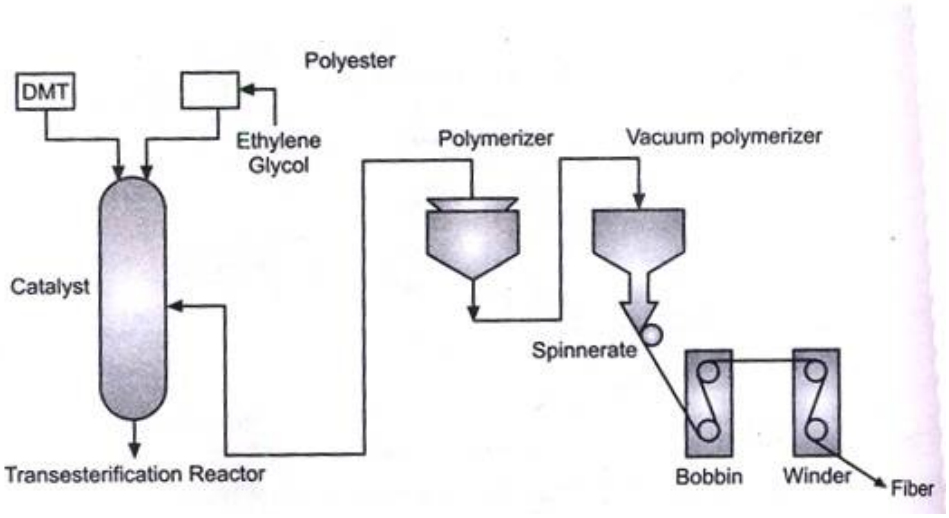
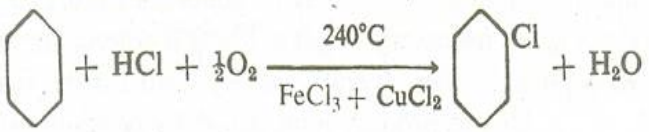
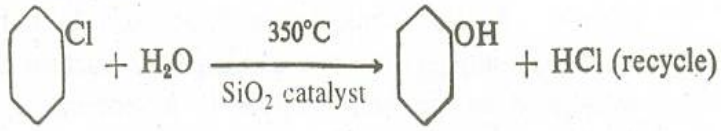
	$[C_6H_7O_2(OH)_3]_n + nNaOH \rightarrow [C_6H_7O_2(OH)_3NaOH]_n$ Cellulose alkali Alkali cellulose  		
5 a)	**Manufacturing process of acetic acid from acetaldehyde** The continuous oxidation of CH_3CHO in liq. phase is carried out by using air or O_2 in presence of manganous acetate. The reaction mix cantaining 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 O_2 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 other volatile components are withdrawn as overhead and residue containing manganous acetate is removed at the bottom.	4 4	8

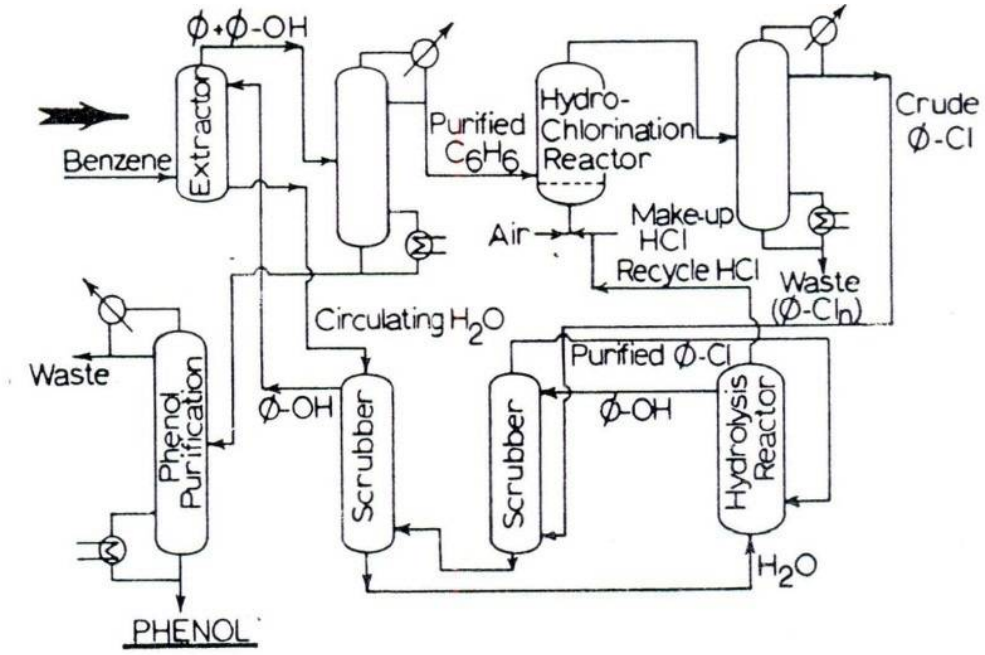
			
b)	**Solvent extraction** : Cakes obtained by pressing operations contain 5 – 10% oils. Further oil is extracted by heating the cake with volatile hydrocarbon like benzene. Petroleum ether, carbon disulphide or carbon tetrachloride are used for the extraction. The common solvent for edible oils is hexane or hexane type naphtha boiling in the range of 146 – 156 ^{o}F. 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.	4	8

	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.  	4	
c)	**Manufacturing of Phenol from Cumene**  Process description: Cumene is mixed with recycle cumene & send to the hydrogenerator. Unsaturated compounds are converted to saturated materials	2	8

	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% H_2SO_4 . 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.  	2 4	
6 a)	**Manufacturing of pulp from sulphate process** 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 plus into	5	8

	lift line where recirculating digestion liquor at 12 atm pressure transfer chips to upper soaking zone of the 25-30 m tall digester tower. 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. 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 going to further processing.  	3	
b)	**Manufacturing of polyester** Process Description: In production of polyester 1mol of DMT & 2 mol of ethylene glycol in presence of catalyst like litharge or zinc, calcium ,magnesium salt or alkali salts are taken and fed to transesterification reactor. The catalyst conc. may vary from 0.005-0.1 %. The reaction starts at 150^{o}C-160^{o}C & methyl alcohol is distilled out until the reaction is complete. At the	5	8

	end of reaction temp will raise upto 2300C. The reaction product is the mix of glycol terephthalate and low polymer. In second stage the temp. is raised further and reaction take place between hydroxyl end group to produce polymer & glycol vacuum slowly and temp raised to remove glycol. Then the polymer is converted to fiber by spannerate & is converted to finished roll by using bobbin & winder.  	3	
c)	**Manufacturing of Phenol by Raschig process** Chemical reactions (a) Hydrochlorination  (b) Hydrolysis  Process description: the Raschig process has two vapour-phase catalyst stages.	2	8

	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 4	