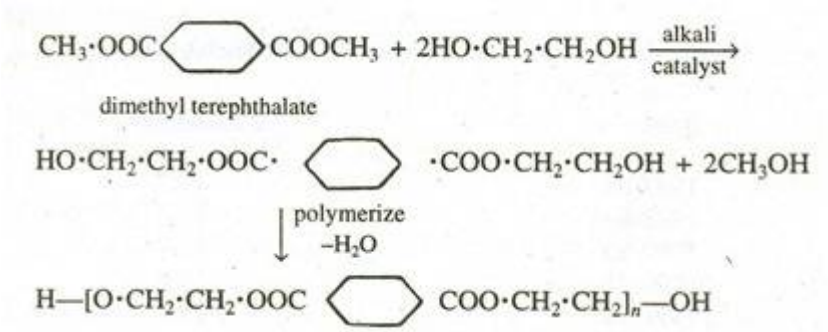
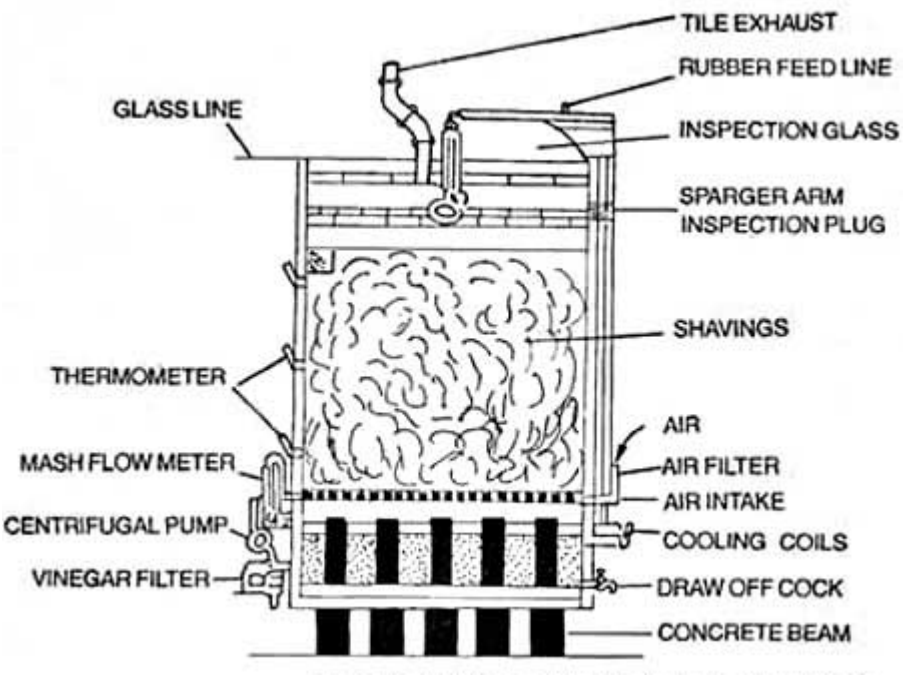
Important Instructions to examiners:

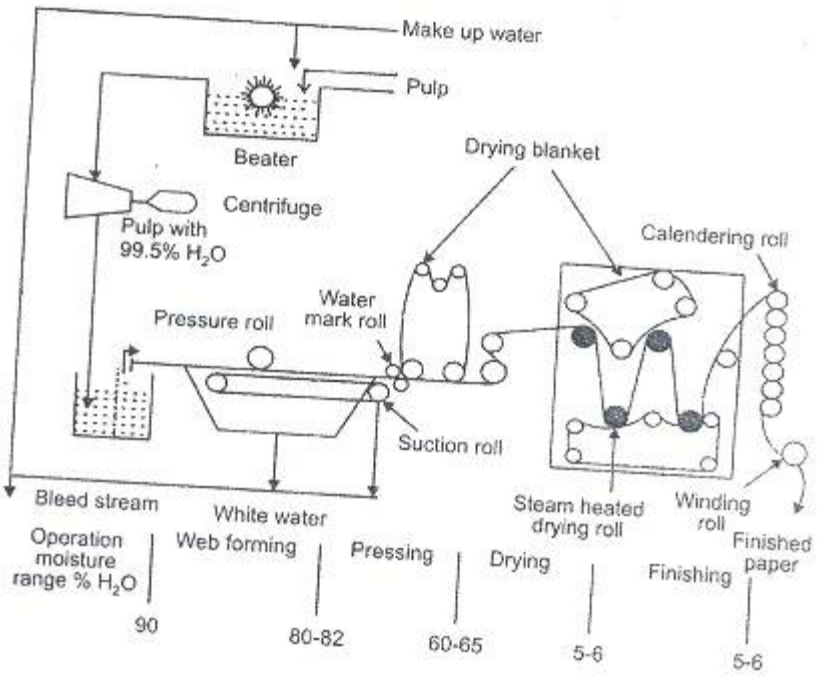
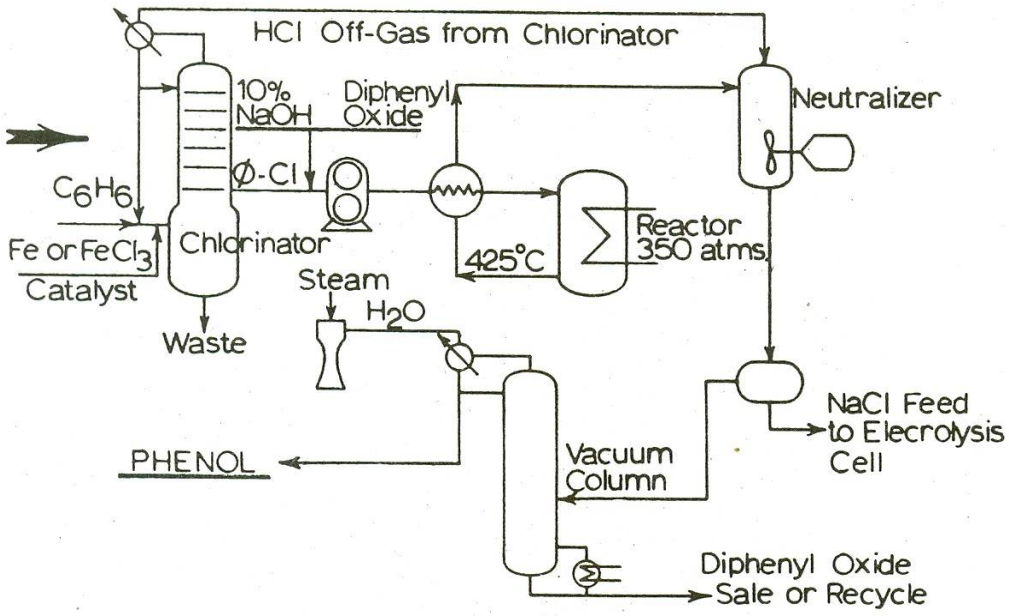
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

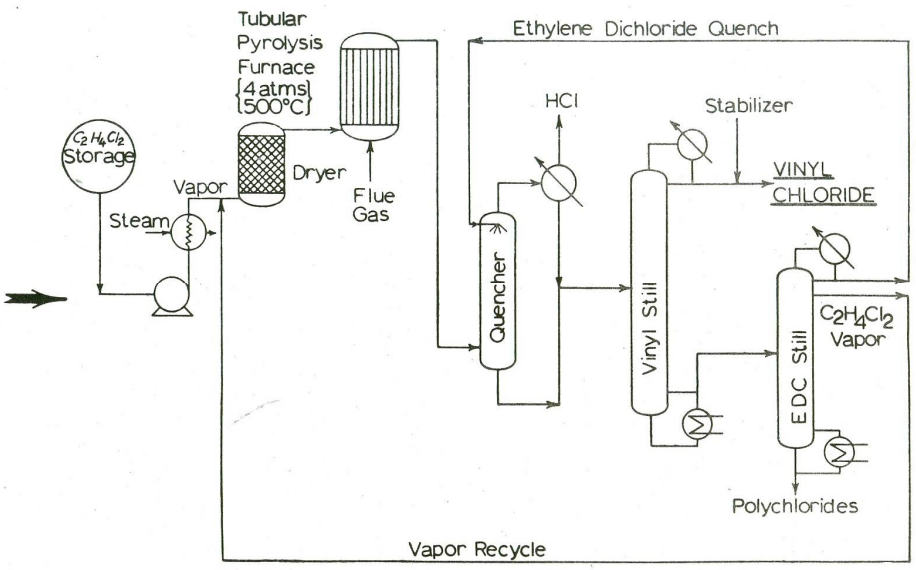
Q No.	Answer	Marks	Total marks
1 a) (i)	**Acid Value** The acid number is defined as the number of milligram of KOH required to neutralize one gram of oil or fat.	2	2
(ii)	Bamboo is preferred raw material in India because • Ample supply • Available throughout the year • Does not deteriorate in storage • High yield of fiber • Low cost	2	2
(iii)	**Factors affecting growth of microorganisms** • pH of medium • Nutrients • Gaseous requirement • Temperature • Light	1 mark for any one	2
(iv)	**Glacial acetic acid:** Acetic acid not containing any water is called glacial acetic acid	2	2
(v)	Polystyrene uses for the production of • Thermocol • Automobile parts • Helmets • Road construction • Acoustic tiles • Surfboards • Seats	1/2 mark each for any four	2

<table>
<tr><td></td><td>• Models</td><td></td><td></td></tr>
<tr><td>(vi)</td><td>Importance of Iodine value-:
i) Iodine value is the measure of unsaturation of oil or fat.
ii) It helps in classification of oils Thus,
1) An oil containing one double bond has iodine value < 90 -Non drying oil
2) An oil containing two double bonds has iodine value <140-Semi-drying oil
3) An oil co containing three double bonds has iodine value >140-drying oil</td><td>2</td><td>2</td></tr>
<tr><td>(vii)</td><td>Saponification value of oil: - It is the number of milligrams of KOH required to saponify one gram of oil.</td><td>2</td><td>2</td></tr>
<tr><td>1 b) (i)</td><td>Pigments: - It finely divided solids generally made up metal oxides.
It is used to give colour to paint and for abrasion resistance.
White pigment -Zinc oxide, titanium oxide
Black pigment -Carbon black
Red pigment- Cadmium selenide
Yellow pigment -Cadmium sulfide</td><td>2
1
1mark for any one pigment</td><td>4</td></tr>
<tr><td>(ii)</td><td>Difference between soap and detergent
<table>
<tr><th>Soap</th><th>Detergent</th></tr>
<tr><td>Soap is sodium salt of fatty acid</td><td>Detergents are salts of organic derivatives of sulfuric acid.</td></tr>
<tr><td>Not work satisfactorily in hard water.</td><td>Can work satisfactorily in hard water.</td></tr>
<tr><td>Yield alkaline solution</td><td>Yield neutral solution</td></tr>
<tr><td>Provide surface action</td><td>Force water to spread and penetrate</td></tr>
<tr><td>Raw material – oil (Fatty acid), caustic</td><td>Raw material – lauryl alcohol, sulphonic acid</td></tr>
</table></td><td>1each for any four points</td><td>4</td></tr>
</table>

(iii)	**Reactions involved in polyester manufacturing**  	4	4
Q 2 a)	**Quick vinegar process:-**  **Process** - In this process 10-13 % alcohol is subjected to bacterial oxidation to form acetic acid. In this process beechwood shaving are inoculated with a species of the genus acetobactor. The solution of alcohol mixed with nutrient for the growth of acetobactor is applied is applied in a trough at the top of	2 2	4

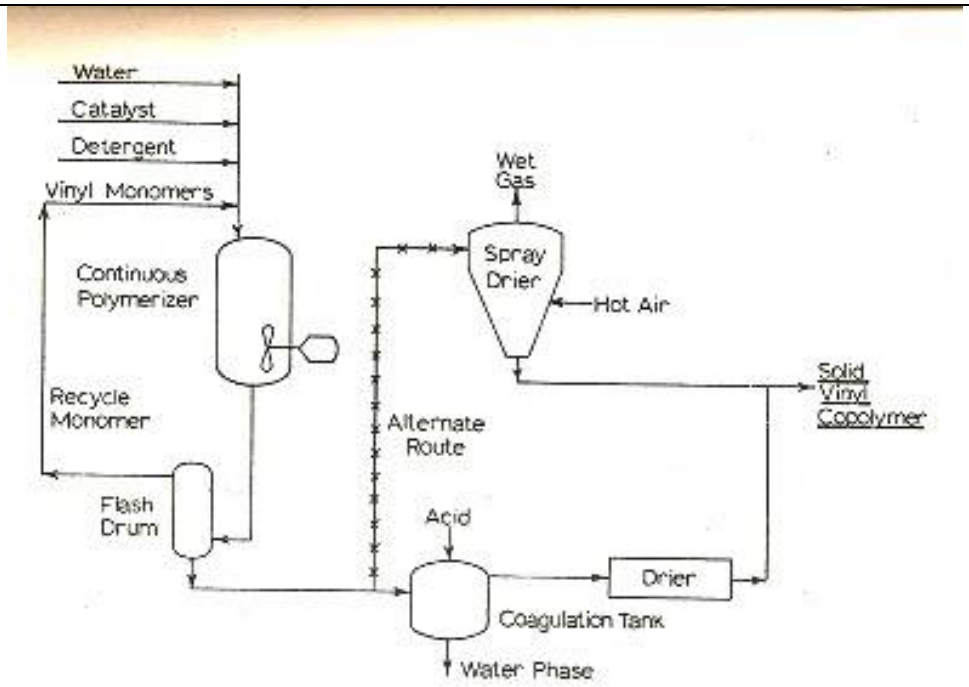
<table>
<tr><td></td><td>chamber , and allowed to trickle down over the shaving . As the mixture passes through the shaving , the acetobactor oxidizes some of the alcohol to acetic acid. The mixture is collected at the bottom. It is re circulated until desired strength is obtained.
$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$</td><td></td><td></td></tr>
<tr><td>b)</td><td>Difference between paint and varnish
<table>
<tr><td>Paint</td><td>Varnish</td></tr>
<tr><td>Paint is the mechanical dispersion mixture of one or more pigments in a vehicle.</td><td>Varnish is a homogenous colloidal dispersion solution of resin in oils or thinner or both.</td></tr>
<tr><td>A paint contains pigment.</td><td>Varnish do not Contain Pigments.</td></tr>
<tr><td>Paint Produce an opaque film.</td><td>Varnish produces transparent film.</td></tr>
<tr><td>In paints pigments are dispersed in drying oils.</td><td>In varnishes resins are dispersed in oils or spirits.</td></tr>
</table></td><td>1each for any four points</td><td>4</td></tr>
<tr><td>c)</td><td>Production of paper from pulp</td><td>4</td><td>4</td></tr>
</table>

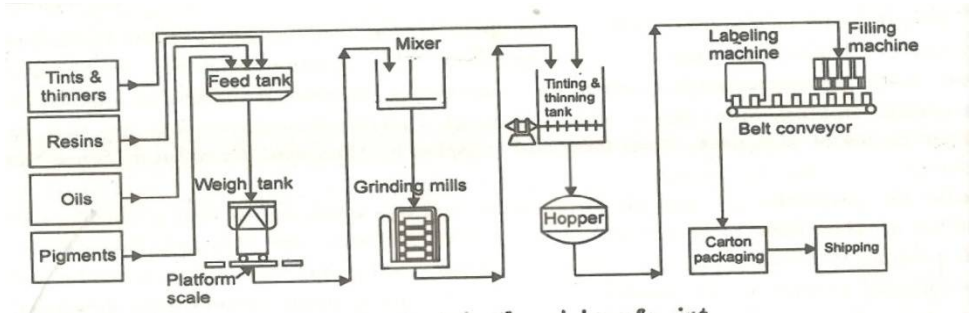
			
d)	**Phenol from chlorobenzene** 	4	4
e)	**Difference between hot and cold process**	1 mark	4

	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.		for each	
f)	**Flow sheet for vinyl chloride** 	4	4
Q 3 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 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 press.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	4	4

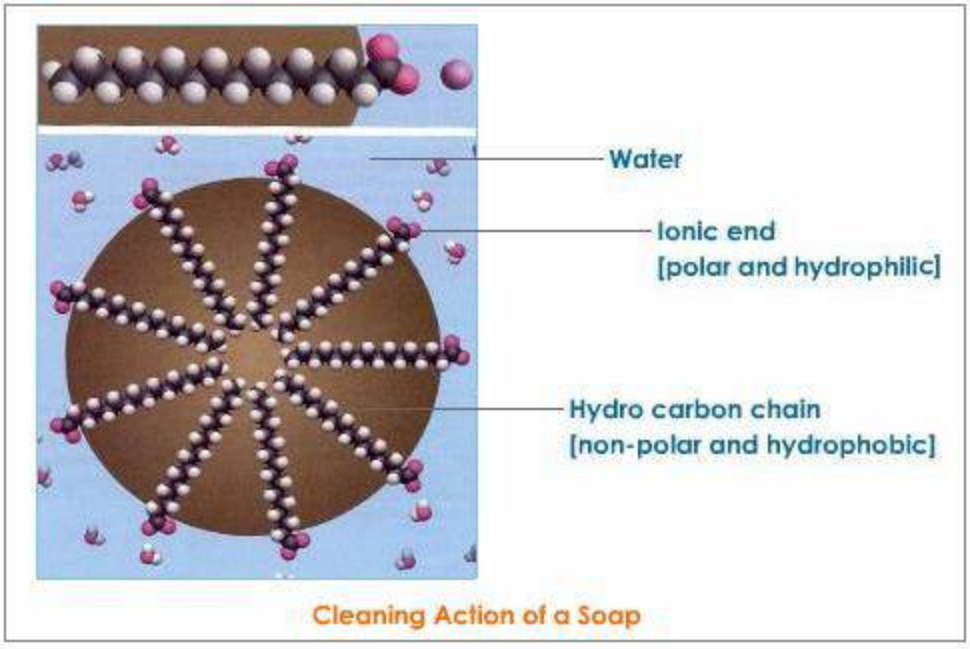
	& converted to the naphthenate for reuse. The unconverted synthesis gas from the oxo converter is recompressed & recycled. The crude butyraldehyde can be fractionated for product sale or continuously hydrogenated using fixed bed Ni catalyst,100 atm,H2 press.,&150 deg.C.The resulting butanols are fed to distillation section compraising several fractionating columns in series.Light & heavy ends as by-product obtained in addition to the purified alcohol.		
b)	**Varnish** Varnish is defined as homogeneous colloidal dispersion solution of natural or synthetic resins in oils or thinner or both. **Types of varnishes** Oil varnishes.(oleo resinous varnishes) Spirit varnishes. **Uses-** For the protection of articles against corrosion As abrightening code to the painted surface Improving the appearance & intensifying the ornamental grains of wood surfaces.	1 1 2	4
c)	**Process of pulp production** 1.Sulphite process 2.Sulphate process or kraft process. **Sulphate process-** Chips are metered by star valve to a deaerater –preheater .After several mins,. Chips are discharged through a rotating tapered plus into lift lined where recirculating digestion liquir at 12 atm. Transfer chips to the upper soaking	1 3	4

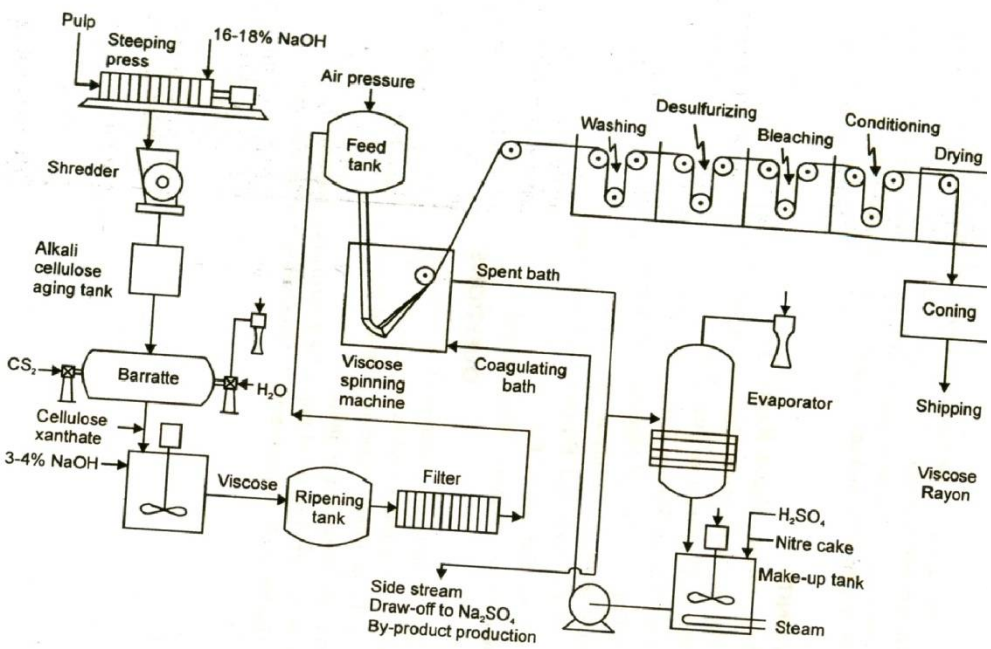
	zone of the 25- 30 m tall digester tower. Chips are blow down passed a series of circumferiancially screen plates.Cooking liquior withdrawn as aside streams & circulated through external heat exchanger to reheat & controlled the digestion temp. Within the tower. The digestion time & temp. Adjusted so that max. Lignin removal is accomplished with min. Cellulose hydrolysis & consequent loss of bulk yield. The digested chips are cooked at the base of tower in junction of black liquor. This is to avoid mechanical weakening of fibres loss from steam explosion of hot liquor,when passed through a blow down valve. Pulp liquor slurry is passed through a valve to a blow tank where residual heat is recovered in the form of steam,which passes overhead with turpentine vapours to the chip preheater.The pulp is filterd to a separate black liquor & screened to remove wood pieces 7 other undigested		
d)	**Phenol from benzene** **Raw material** Benzene, hydrochloric acid , air, water **Reaction** $C_6H_6 + HCl + ½ O_2 \rightarrow C_6H_5Cl + H_2O$ $C_6H_5Cl + H_2O \rightarrow C_6H_5OH + HCl$ (Or any other process where benzene is used as raw material)	2 2	4
e)	**PVC by emulsion polymerization**	4	4

			
f)	**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
Q 4 a)	**Zeigler process-** Catalyst is prepared by adding diethyl aluminum chloride and titanium tetrachloride as Co catalyst at pressure 15 to 100 psi and the temp raise to 20-70 deg.C in about 10 min. The product from reactor is taken to the flash drum, here water is added to destroy residual catalyst. The bottom product from flash drum is aq slurry of polyethylene which is separated from aq. Filtrate The overhead product of flash drum containing hydrocarbon solvent is treated in	4	4

	fractionater drier & recycled for reuse.		
b)	**Paint**  The weighing assembling, and mixing of the pigments and vehicles takes place on the top floor. The mixer may be similar to large dough kneader with sigma blades. The batch masses are conveyed to the floor below, where grinding & further mixing takes place. A variety of grinding mills are used. After mixing, the paint is transferred to the next to the next lower floor, where it is thinned & tinted in agitated tanks, which may hold batches of several thousand litres. The liquid paint is strained into a transfer tank or directly into the hopper of the filling machine on the floor below, centrifuges ,screens or press. Filters are used remove non dispersed pigments. The paint is poured into cans or drums, labelled,packed & moved to storage each step being completely automatic.	2 2	4
c)	**Industrial uses of alcohol** • In manufacturig of alcoholic beverages • as asolvent for paints & varnishes • in drug preparation • in mfg. of chloform • acetaldehyde and synthetic rubber,	1 mark each for any four uses	4

	• as antifreeze in automobile radiaters		
d)	**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	4

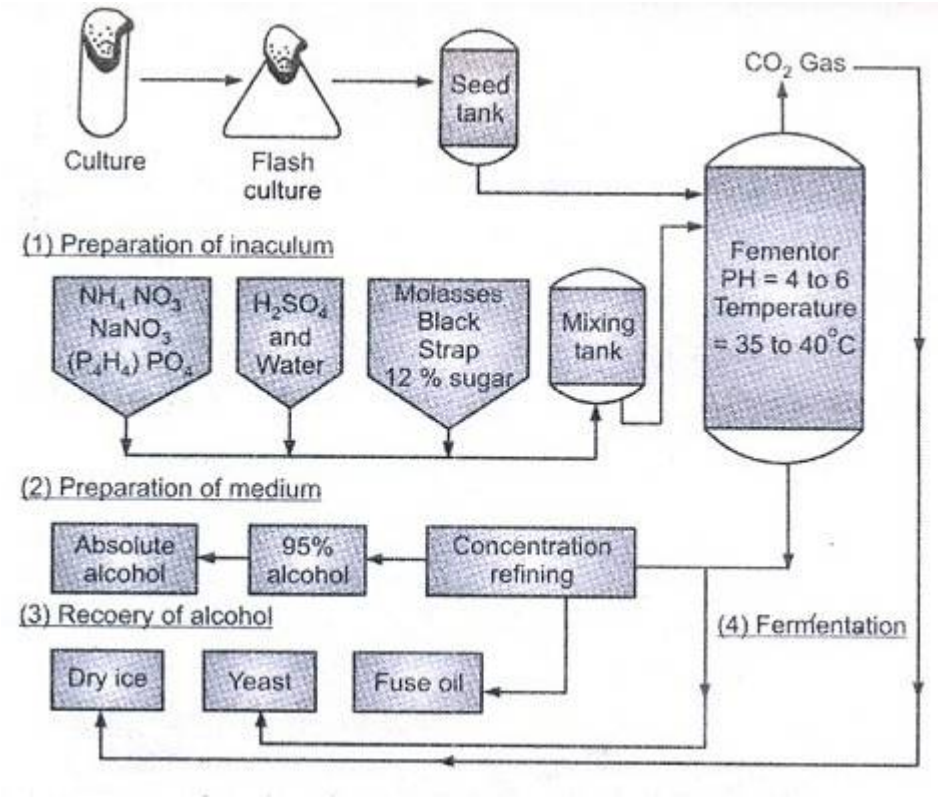
		1	
e)	**Oil extraction** **Mechanical process-** Oilseeds or nuts are passed over magnetic separators, where by iron particles are removed. Large size impurities are removed by screening. Dirt ,small sticks and other impurities are removed by blowing with air.The cleaned oilseed are then introduced into the crushing chamber Seeds are crushed between I&II & then between II & III rolls.Thus the process continues till the crushed material falls on the guide plate of the V roll. **Hydraulic pressing-** Using hydraulic press, These bags are repeatedly squeezed, whereby oil flows out. It is collected in the storage tank. The process of pressing is repeated to take out maximum amount of oil, when the squeezed material is converted into cakes.	2 2	4
f)	**Rayon manufacturing flowsheet**	4	4

			
Q 5 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	3	8

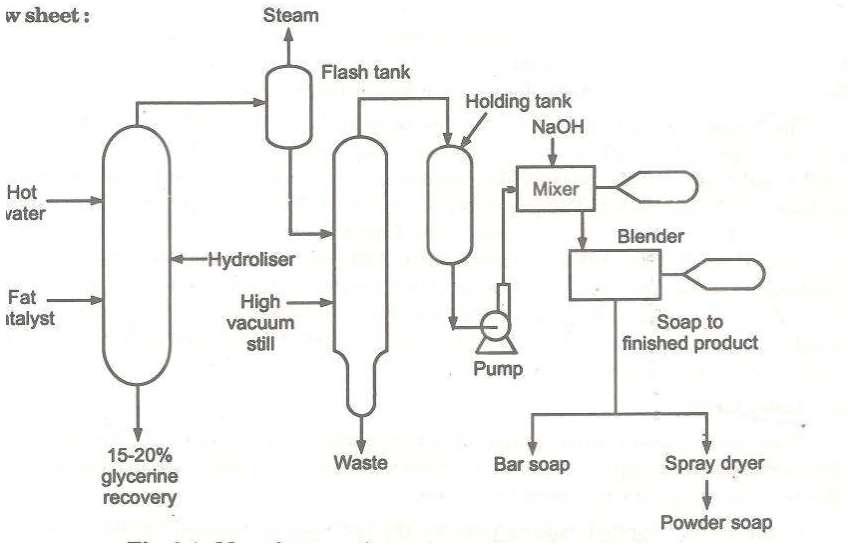
	and mutation. **iii. Preparation of medium :**The molasses is difuted with water to 10 to 18%. These molasses can be used directly as fermentation medium. Nutrients such as ammonium sulphates or ammonium phosphate may be added to improve the quality of fermentation. The pH value of the medium is adjusted 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 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. "invertase $C_{12}H_{22}O_{11}$ = $C_6H_{12}O_6 + C_6H_{12}O_6$ Yeast Sucrose Glucose Fructose zymase $C_6H_{12}O_6$ = $2C_2H_5OH+2CO_2$ Yeast Glucose or Ethanol Fructose	2	

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.

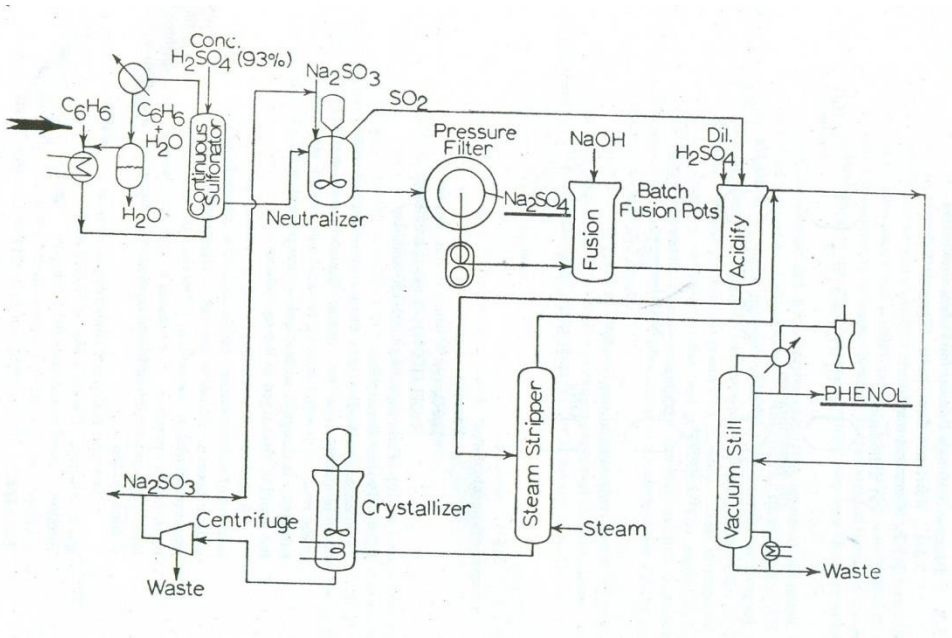
To prepare absolute ethanol, the 5% water is removed by forming aazeotropic mixture of benzene, water and ethanol which is then distilled with increasing temperature.



3

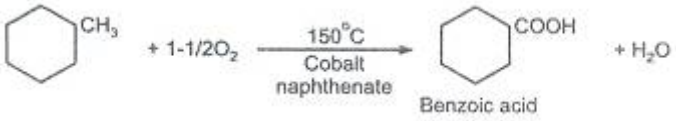
b)	**Soap** **Process** Glycerides plus catalyst are added at the bottom of the hydrolysis tower where high pressure water at 230-250oC is passed countercurrently to the glycerides. And triglycerides are brake into fatty acid and glycerine with a 15-20% glycerine solution being removed from bottom of the tower . The fatty acid are passed overhead to a flash tank to remove excess steam. The crude fatty acid are vaccum distilled and the condensate in the distillate receiver is either available as a marketable product or for soap mfg. Caustic soda is added to fatty acid in a continuous high speed mixture 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 bar soap or flake or spray drying equipments followed by packing operations.  **Chemical Reaction -:** **a) Fat splitting-:**	4 2	8

	(R.COO)3. C3H5 + 3H2O →3R.COO.H + C3H5(OH)3 **b) Saponification**-: R.COO.H + M . OH →R.COO.M + H2O Where M is usually an alkali metal such as **Na** or **K**	2	
c)	**Phenol by benzene sulphonate process** **Reactions :** a) Sulphonation : $C_6H_6 + H_2SO_4 \rightarrow C_6H_5\text{-}SO_3H + H_2O$ b) Neutralization : $2C_6H_5\text{-}SO_3H + Na_2SO_3 \rightarrow 2C_6H_5\text{-}SO_3Na + SO_2 + Na_2SO_4$ c) Fusion : $C_6H_5\text{-}SO_3Na + NaOH \rightarrow C_6H_5\text{-}ONa + SO_2$ d) Acidification : $C_6H_5\text{-}ONa + H_2SO_4 + SO_2 \rightarrow C_6H_5\text{-}OH + Na_2SO_3 + Na_2SO_4$ **Process description :** Benzene sulphonic acid is formed by contact of benzene vap. With H_2SO_4 liquid in a counter current reactor. Excess benzene carries off the water form in the reaction to avoid the diluting the acid and slowing down the sulphonation. The sulphonator is designed so that only a few percent of free H_2SO_4 remains	2 2	8

	before the liquid is discharged to the neutralizer . Neutralisation is accomplished by rapidely adding the reactor liquor to a solution of sodium sulfite . Sulphur dioxide is released and the pot residue contains sodium benzene sulphonate in a solution and precipitated Na_2SO_4 . This mixture is pressure filtered at the B.P with the clear solution moving onto the batch fusion operation. In a process modification some plant centrifuge the hot liquor concentrate the sulfonate liquor further by evaporation then removed more sodium sulfate . A cast iron fusion pot containing molten caustic is kept at 300^0c by the direct gas or oil fire. The sulfonate is slowly added at the bottom of the pot and the reaction allowed to continue for 5-6 hrs. The melt is then diluted with water ,acidified with SO_2 from the neutralization step and the final PH adjusted with H_2SO_4 . The released crude phenol floats on an aq. Solution containing sodium sulphate, sodium sulfite and small percentage of phenol.  	4	
Q 6 a)	**Phenol production**		8

Chemical reaction :

(a) Oxidation to benzoic acid :



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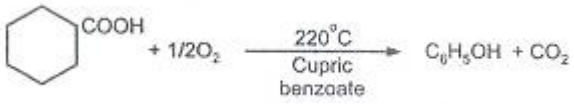
(b) Oxidation of benzoic acid to phenol :



Process Description :

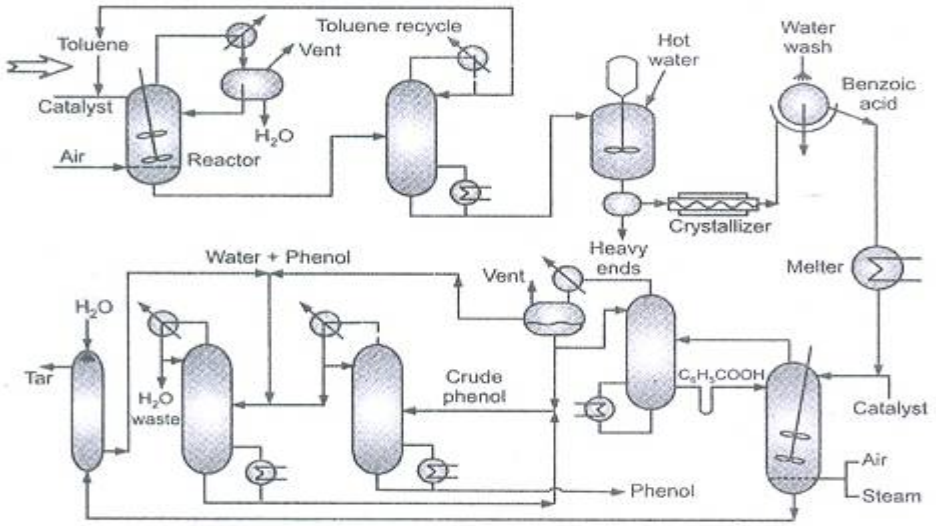
A two-stage air oxidation process is used. In the first stage, fresh plus recycle toluene are mixed with a small quantity of cobalt naphthenate catalyst and charged to the reactor which is a liquid-filled tower through which air is sparged. Cooling tubes are provided to remove the exothermic heat of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

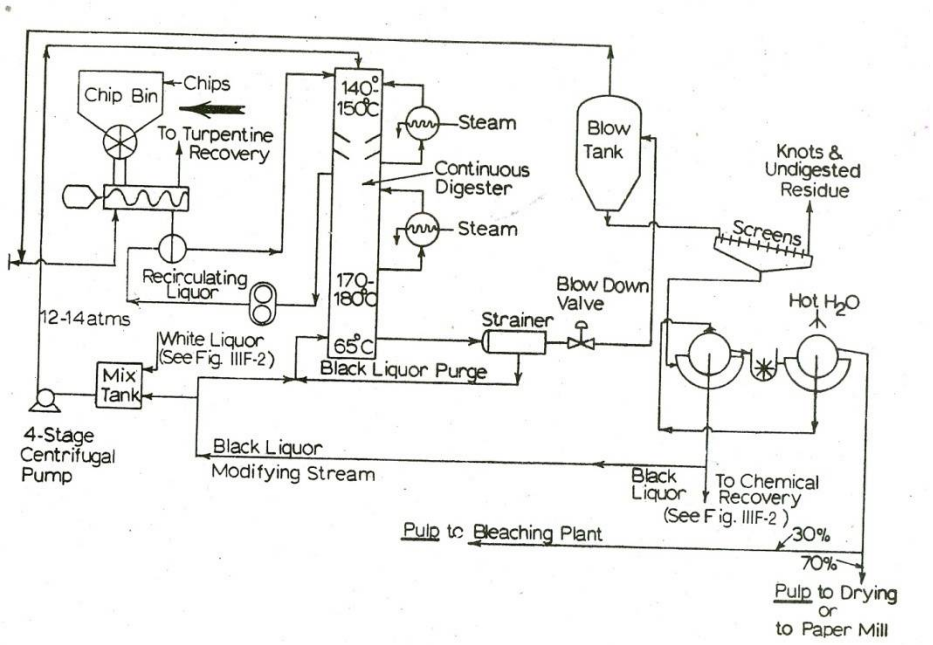
3

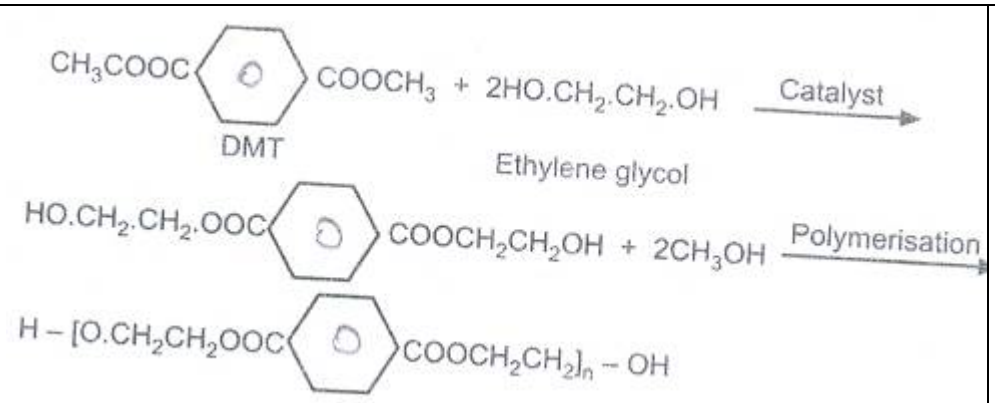
The reactor is run at 150^{o}C and 3 atms. Excess air is used, but toluene conversion is limited to 40% to avoid excessive side reactions, These give by-products such as benzaldehyde, benzyl alcohol, benzyl benzoate, CO and CO_2.With conversion of toluene at 40% the ultimate yield of benzoic acid is about 90%.

Off-gases 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. **Flow Sheet :**	3	

	 **Flow sheet for manufacturing of Phenol from Toluene oxidation**		
b)	**Kraft Process** The wooden chips are metered via star valve to a deaerator preheater . After several minutes, the chips are discharged through a rotating tapered plug into the lift line where recirculating digestion liquor at 12 atms. Transfers chips to the upper soaking zone of the 25-30m tall digester tower. Chips flow down past a series of circumferential screen plates. Cooking liquor is withdrawn as side streams and circulated through external heat exchangers to reheat and control the digestion temp. within the tower. The digestion time and temp. is adjusted so that max lignin removal is accomplished with a minimum cellulose hydrolysis and consequent loss of bulk yield. The digested chips are cooled at the base of tower by injection of cold black liquor. This is to avoid mechanical weakening of fibers from steam explosion	4	8

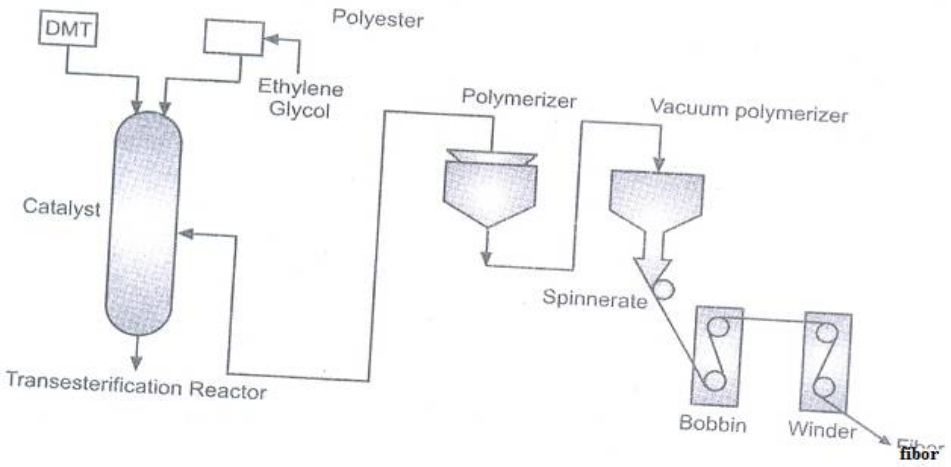
	of hot liquor when passed through a blow down valve. The pulp liquor slurry is passed through the valve to a blow tank where residual heat is recovered in the form of steam. which passes overhead with turpentine vap. To the chip preheater. The pulp is filtered to separate black liquor and screened to remove wood knots and other undigested residue.  	4	
c)	**Polyester** **Raw Materials** (1) Dimethyl terephthalate. (2) Ethylene glycol. (3) Catalyst : Litharge or zinc salt, calcium , magnesium or alkali salt, etc. **Reactions :**	3	8



Process Description :

In production of polyester, one mole of DMT and two moles of ethylene glycol in presence of catalyst like litharge or zinc, calcium, magnesium salt or alkali salt are taken and fed to trans-esterification reactor. The catalyst concentration may vary from 0.0005 to 0.1%. The reaction start at 150^{o}C to 160^{o}C and methyl alcohol is distilled out until the reaction is complete. At the end of reaction, the temperature will raise up to 230^{o}C . The reaction product is a mixture of glycol terephithalate and low polymer. 3

In second stage, the temperature is raised further and reaction takes place between hydroxyl end group to produce polymer and glycol vacuum applied slowly and temperature raised to remove ghlycol. Then the polymer is converted to fibre by spannerate and is converted to finished roll by using bobbin and winder. 2

	 DMT Polyester Ethylene Glycol Polymerizer Vacuum polymerizer Catalyst Spinnerate Transesterification Reactor Bobbin Winder fibor		