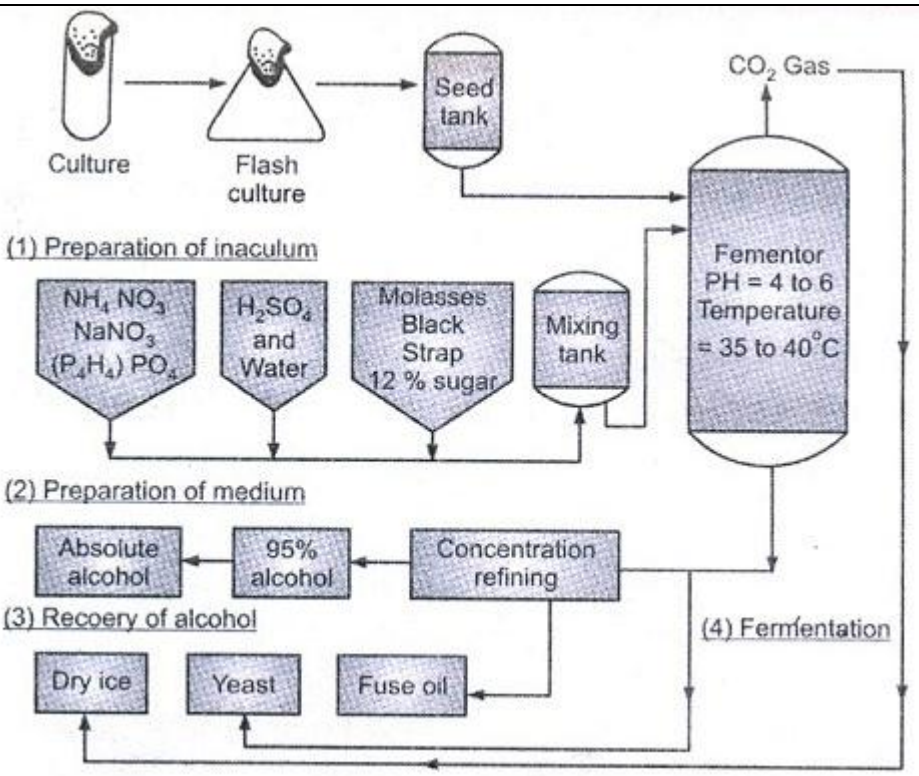
Important Instructions to examiners:

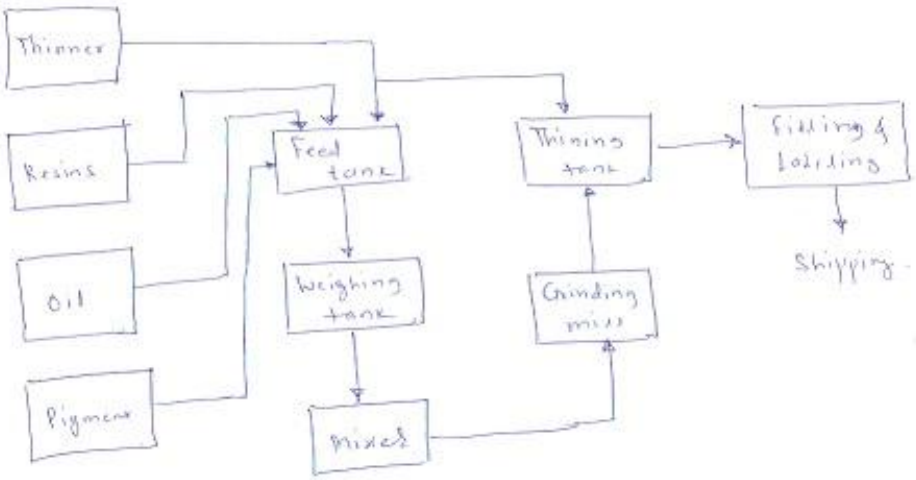
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

Q No.	Answer	Marks
1a	**Attempt any six**	12
i)	**Fermentation:** The chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat.	2
ii)	**Sources of cellulose Pulp** • Babmoo • Agricultural residue • Bagasse, • Cereal straw • Reeds • Esparto grass • Jute • Flax • Sisal • Softwood (spruce, pine, fir, larch, aspen, eucalyptus)	½ mark each for any four
iii)	**Saponification value** It is the no. of milligrams of KOH required to saponify one gram of an oil or fat. **Iodine value** Iodine value is the no. Of grams of iodine absorbed by 100 grams of oil or fat for its complete saturation.	1 mark each
iv)	**Various Methods for phenol manufacturing** 1. Cumene peroxidation – hydrolysis 2. Toluene two – stage oxidation.	½ mark each for any

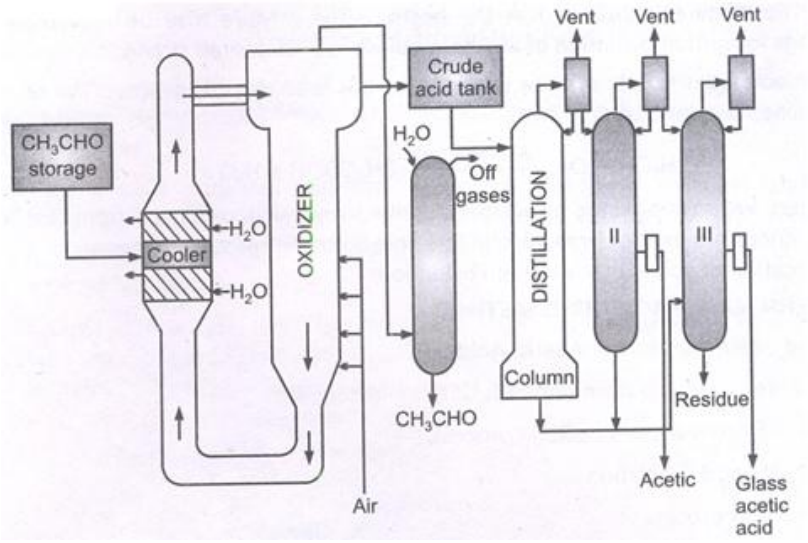
	3. Rasching : vapour phase hydrochlorination & hydrolysis. 4. Chlorobenzene - caustic hydrolysis. 5. Benzene sulfonate – caustic fusion. 6. Benzene – direct oxidation.	four
v)	**Uses of :** *Polyester:* Textile, fishing nets, filter cloth. Conveyor belt *Poly vinyl chloride*: Pipes, raincoats, cables, vinyl flooring	½ mark for 2 uses of each
vi)	**Constituents of paint** Pigments Drying oil Thinners or solvent Plasticizer	½ mark each.
vii)	**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.	1 1
1b	**Attempt any two**	**8**
i)	**Alcohol from molasses**	4

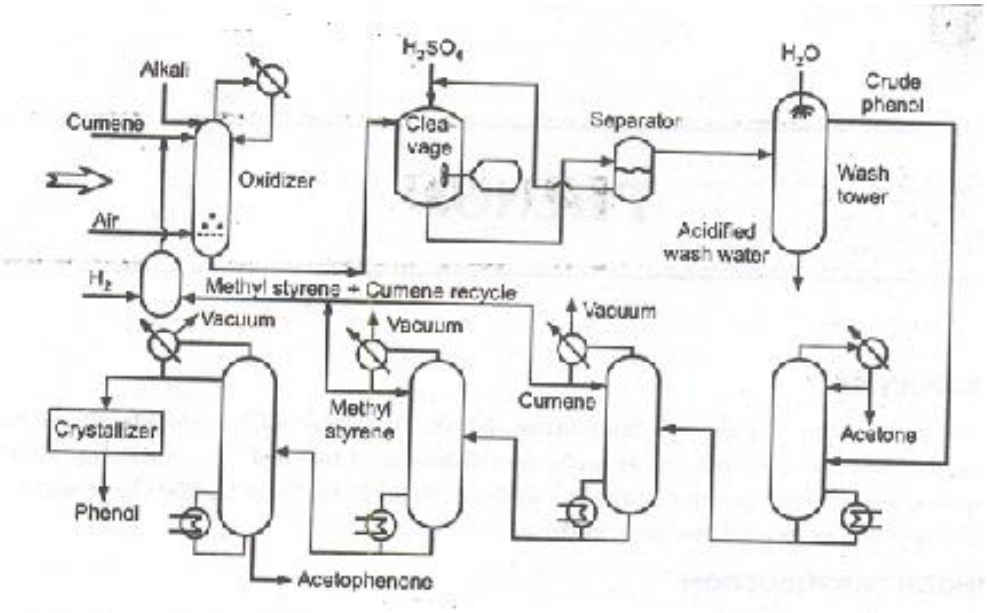


ii) **Block diagram of paint production** 4

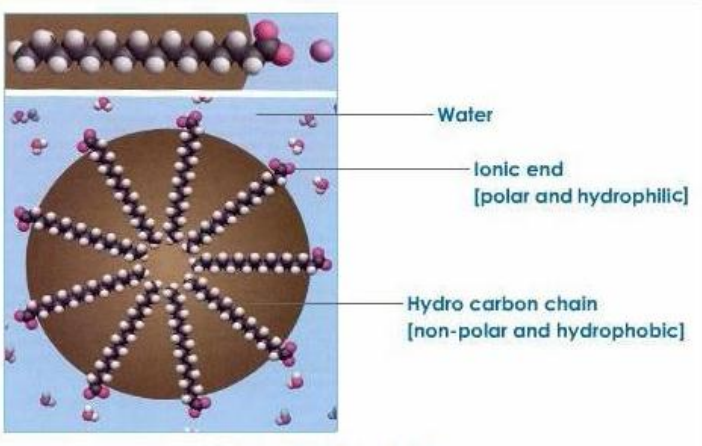


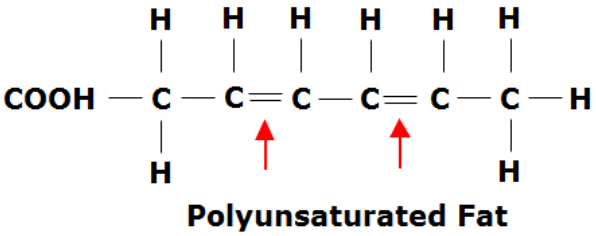
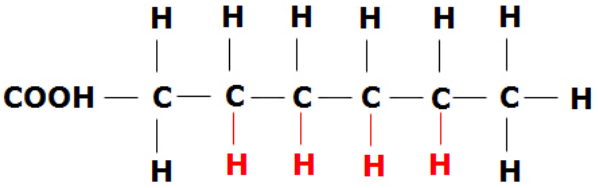
iii)	**Polymer:** A substance which has a molecular structure built up chiefly or completely from a large number of similar units bonded together, e.g. many synthetic organic materials used as plastics and resins. **Polymerization** is the process of connecting these monomers together and creating large macromolecules of different sizes and shapes. Polymerization is similar to constructing a large building out of the same type of Lego blocks. The blocks can be connected in various ways to create a larger, more intricately shaped structure than the original Lego block on its own. The two major types of polymerization are addition polymerization and condensation polymerization. *Addition Polymerization* Polymerization that occurs through the coupling of monomers using their multiple bonds is called addition polymerization. The simplest example involves the formation of polyethylene from ethylene molecules. In this reaction, the double bond in each ethylene molecule opens up, and two of the electrons originally in this bond are used to form new carbon-carbon single bonds with two other ethylene molecules. *Condensation Polymerization and Hydrolysis* The chemical mechanism that cells use to make and break polymers are basically the same in all cases. Monomers are connected by a reaction in which two molecules are covalently bonded to each other through loss of a water molecule; this is called a condensation polymerization because the lost molecule is water. When a bond forms between two monomers, each monomer contributes part of the water molecule that is lost; one molecule provides a hydroxyl group, while the other provides a hydrogen. To make a polymer, this reaction is repeated as monomers are added to the chain one by one.	1 1 1 1

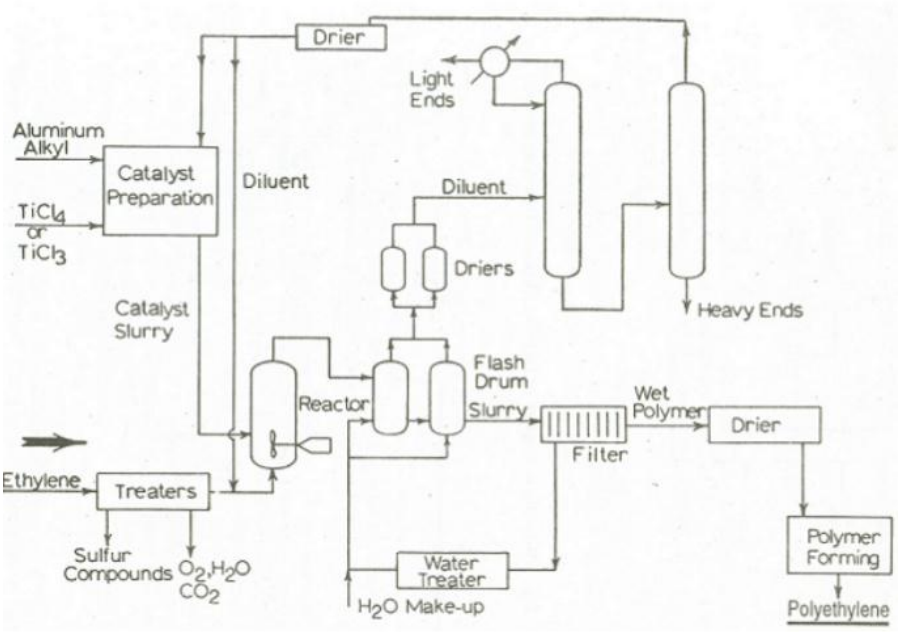
2	Attempt any four	16
a)	**Manufacturing process of acetic acid from acetaldehyde** The continuous oxidation of CH_3CHO in liq. phase is carried out by using air or O_2 in presence of manganous acetate. The reaction mix cantaining CH3CHO diluted with crude acid & manganous acetate solution is circulated 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. **Reaction** $CH_3CHO + ½ O2 = CH_3COOH$  	2 2

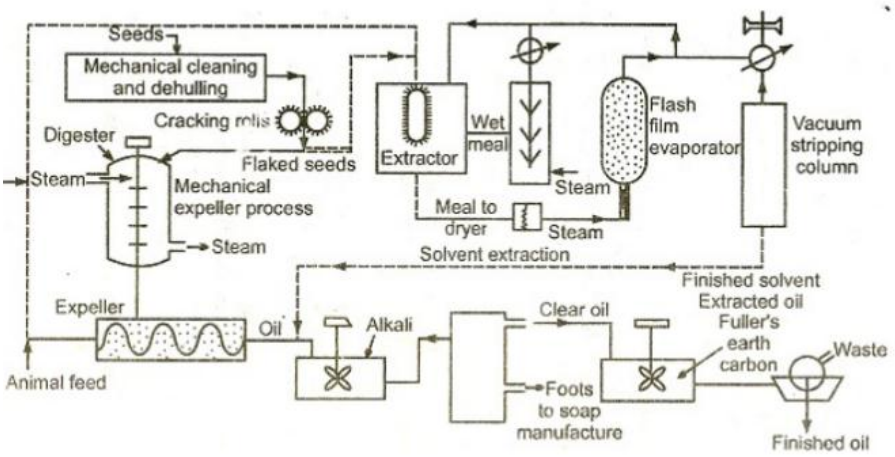
b)	**Types of plastic** **Thermoplastics** which are softened by heat and can be moulded. (Injection moulded, blow moulded or vacuum formed). Good examples are acrylic, polypropylene, polystyrene, polythene and PVC. **Thermosets** which are formed by ha heat process but are then set (like concrete) and cannot change shape by reheating. Good examples are melamine (kitchen worktops), Bakelite (black saucepan handles), polyester and epoxy resins.	2 2
c)	**Phenol from Cumene** 	4
d)	**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	1 mark each for any 4

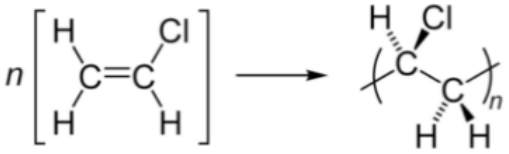
<table>
<tr><td></td><td>Groundwood printing paper:- To make catalogue, newsprint, poster
Paperboard:- boxes, cartoons</td><td></td></tr>
<tr><td>e)</td><td>Difference between sulphate and sulphite process
<table>
<tr><th>Sulphate Process</th><th>Sulphite Process</th></tr>
<tr><td>This process is alkaline 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 process es. (any four)</td></tr>
<tr><td>f)</td><td>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</td><td>3</td></tr>
</table>

	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.  	1
3	**Attempt any four**	**16**
a)	**Soap**: Soap are the sodium salt of long chain fatty acids or carboxylic acids. **Hot Process :** Glycerides plus catalyst are added at the bottom of the hydrolysis tower where high pressure water at 230-250oC is passed counter currently to the glycerides. And triglycerides are brake into fatty acid and glycerin with a 15-20% glycerine solution being removed from bottom of the tower. The fatty acid is passed overhead to a flash tank to remove excess steam. The crude fatty acid are vacuum 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 equipment's followed by packing operations.	1 3

b)	**Conversion of oil into fats:** Oils are converted into fats by hydrogenation of oil. For edible purpose and some industrial applications it is desirable to have solid fats. Fats or oils containing unsaturated fatty acids can be hydrogenated to produce fats containing saturated glycerides. The liquid fats can be converted to solid fats. Partial hydrogenation can also be carried out to obtain the semi-solid product. Such controlled hydrogenation is commercially used in the production of margarine from vegetable fats. Hydrogen can be added to double bond. This requires high pressure and a catalyst such as platinum, nickel or palladium.  Polyunsaturated Fat Hydrogenation  Hydrogenated Fat	2 2
c)	**Ziegler process for the manufacturing of polyethylene**	4

		
d)	**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 is used for the extraction. The common solvent for edible oils is hexane or hexane type naphtha boiling in the range of 146 –156 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. 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	2

	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.  	2
e)	**Constituents of paint** Pigments Drying oil Thinners or solvent Plasticizer	1 mark each
f)	**PVC by emulsion polymerization** $CH_2=CH_2 + Cl_2 \rightarrow CH_2ClCH_2Cl$ $CH_2ClCH_2Cl \rightarrow CH_2=CHCl + HCl$	2



In emulsion polymerisation, a typical formulation is100 parts of water, 100 parts of vinyl monomer,1 part of catalyst per sulfate 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 stabilized by addition of more emulsifying agent and solid as vinyl latex. For solid polymer, mixture acid coagulated and dried or spray dried. — 2

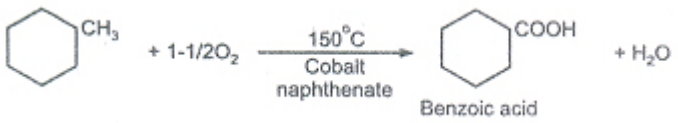
4 **Attempt any four** — **16**

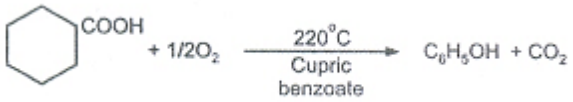
a) **Difference between varnish and lacquer** — 1 mark each for any two

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 or polymerisation	Mode of drying - Evaporation

b) **Hydrogenation of Oil** — 4

The dry pure oil and nickel catalyst is taken in an iron cylinder. The cylinder has two inlets & outlets. One inlet is used for the introduction of oil & the other to introduce dry hydrogen. Unused hydrogen is removed through the

	upper outlet, while lower outlet is used to take the hydrogenated oil. The cylinder is provided with stirrer inside it. The temp. is regulated between1400C-180oC. From the second inlet, pure hydrogen gas is well mixed with the oil. In the cylinder oil &dry hydrogen gas are well mixed with mechanical stirrer. After certain time a sample of hydrogenated oil is taken through outlet is situated at the bottom of the cylinder. The iodine value of the hydrogenated oil is determined. If it is 60, the process of hydrogenation is stopped. And all the hydrogenated oil is taken out It is passed through cooler then filter pressed to remove nickel particles.	
c)	**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
d)	**Saponification value of oil**: It is the number of milligrams of KOH required to saponify one gram of oil. **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
e)	**Phenol production from toluene** **(a) Oxidation to benzoic acid :** 	2

	(b) Oxidation of benzoic acid to phenol :  	2
f)	**Thermocol** First, styrene is made by combining ethylene and benzene. Next, the styrene is subjected to suspension polymerization and treated with a polymerization initiator, which together convert it into polystyrene. Once a polymer chain of the desired length has formed, technicians stop the reaction with terminating agents. The resulting polystyrene beads are then cleaned, and anomalous beads filtered out. To make thermocol, workers then melt, add a blowing agent to, and extrude the beads. To produce smooth-skinned thermocol, they pre-expand the beads, dramatically reducing their density. Next they heat and expand them before allowing them to sit for 24 hours so that they can cool and harden. The beads are then fed into a mold of the desired shape.	4
5	**Attempt any two**	**16**
a)	**Raw materials for butanol** Propylene , Hydrogen, Synthesis gas **Reaction** (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 $C_3H_7CHO + H_2 \xrightarrow[150°C, 100 atms.]{\text{Ni catalyst}} C_3H_7CH_2OH$	1 1

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.

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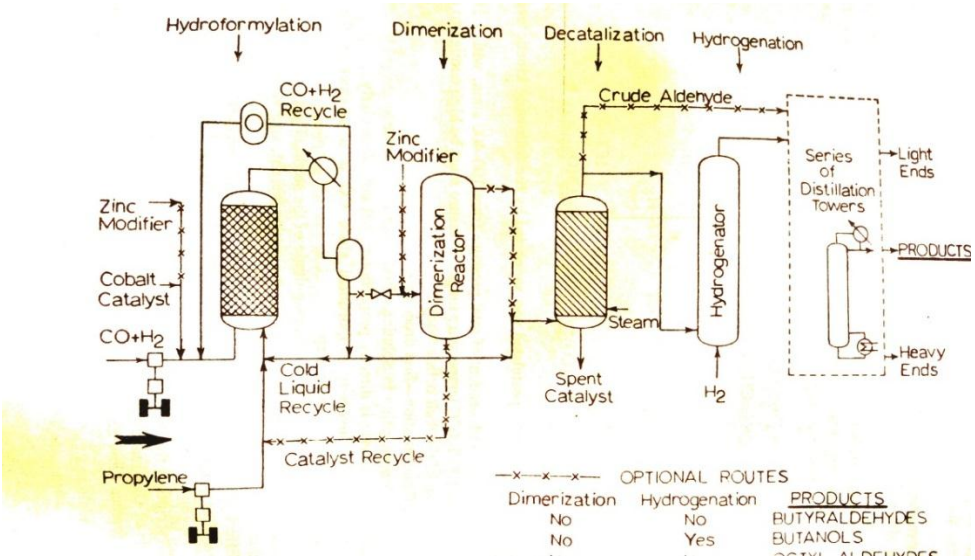

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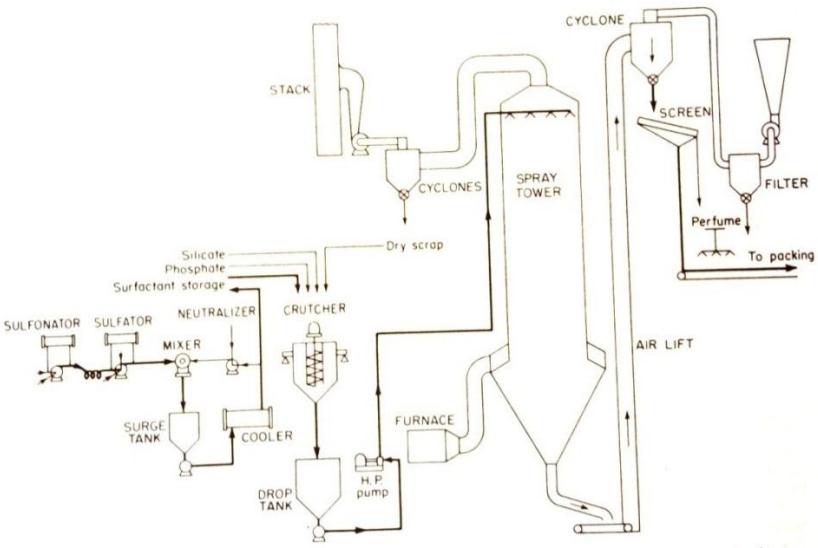
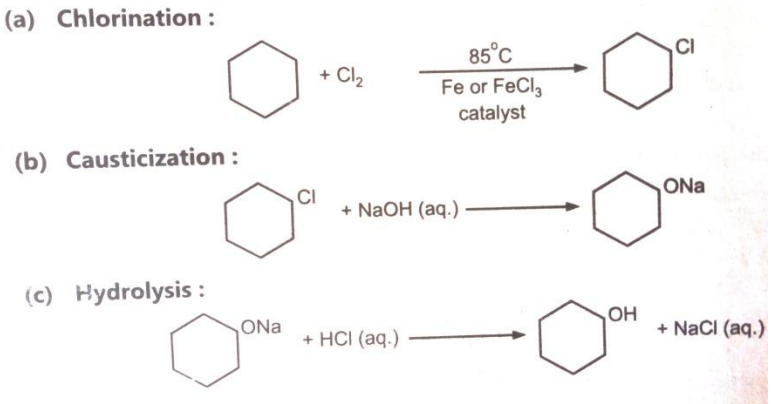
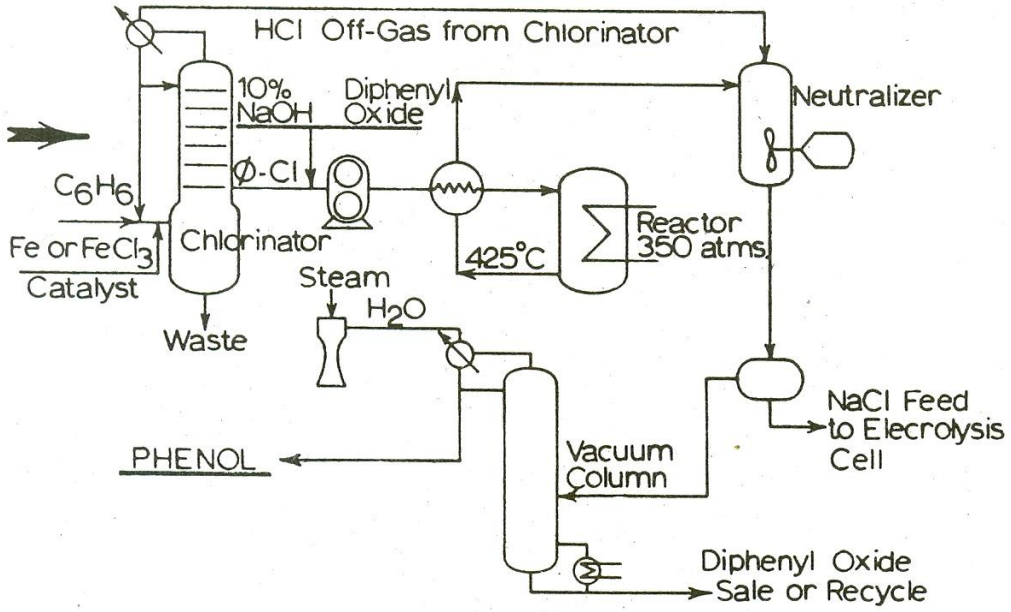
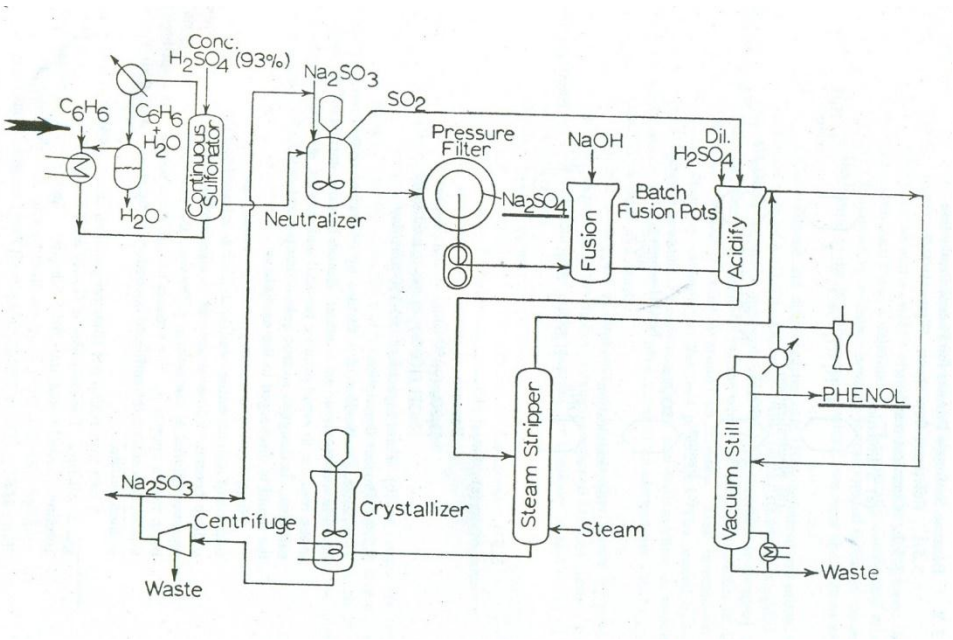
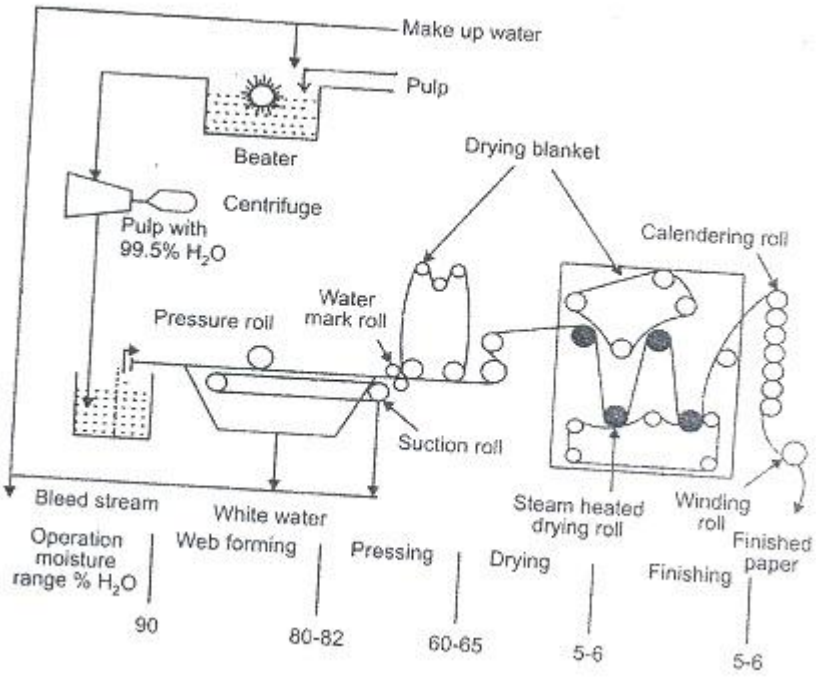
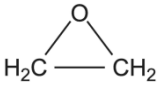
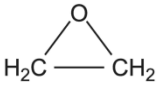
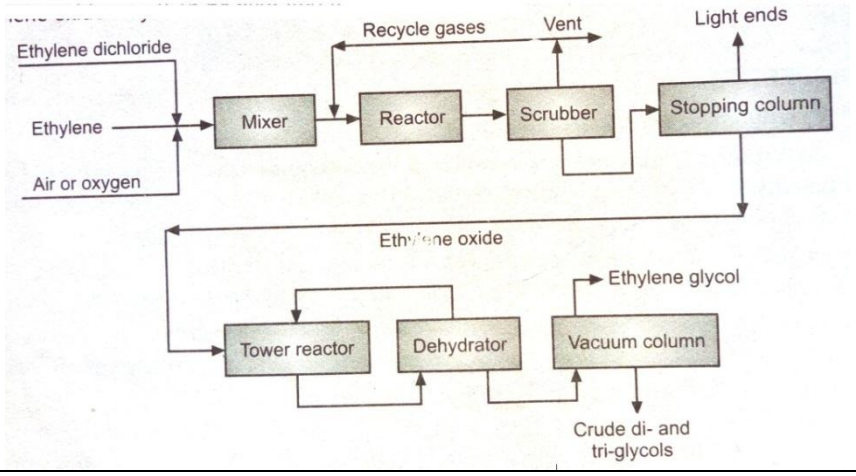
b)	**Manufacturing of detergents**.  The alkyl benzene is introduced continuously into sulfonator with the requisite amount of oleum, using the dominant batch principle. To control the heat of sulphonation conversion and maintain the temperature at about 55^{o}C. Into the sulfonation mixture is fed the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

	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.	
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. 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^{o}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**  	2 2

		4
6	**Attempt any two**	**16**
a)	**PFD : Phenol by benzene sulfonate** 	**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 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	**4**

	packaged.  	**4**
c)	**Ethylene glycol: Process is carried out at different steps** **Ethylene oxide production.** Ethylene and oxygen are fed to a multi-tubular reactor, forming EO. This exothermic reaction, conducted in fixed beds in the reactor tubes, occurs in the gaseous phase with the use of a silver catalyst supported on alumina. Steam is generated by the heat of reaction. **Ethylene oxide recovery.** The reactor product stream is fed to the EO absorber for lights removal by water quenching. Part of this gaseous overhead stream is recycled to the reactor, while the other part is sent to a carbon-dioxide-removal unit composed of an absorber and a stripper. In this unit, CO2 is separated to be used in ethylene carbonate production. A diluted EO stream removed from the absorber is fed to the EO stripper,	**(Out of syllabus)** **2**

	where it is concentrated and recovered in the overheads. The crude EO stream is condensed. Residual light gases are recovered from it and recycled to the reactor. The resulting EO stream is directed to the next section. **Ethylene glycol production and purification.** Ethylene oxide is reacted with CO2, forming ethylene carbonate, which is then hydrolyzed to form MEG and CO2. Both reactions are carried out in the liquid phase using homogeneous catalysts. CO2 streams from the reaction steps are recycled to the ethylene carbonate reactor. MEG is purified in two distillation columns where water is removed, leading to the final MEG product. The catalyst is separated and recycled to the ethylene carbonate reactors. **Reaction** $H_2C = CH_2 + ½\ O_2 \rightarrow$   $+ H2O \rightarrow HO\text{-}CH_2\text{-}CH_2\text{-}HO$ 	**2** **2** **2**