MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

SUMMER-13 EXAMINATION

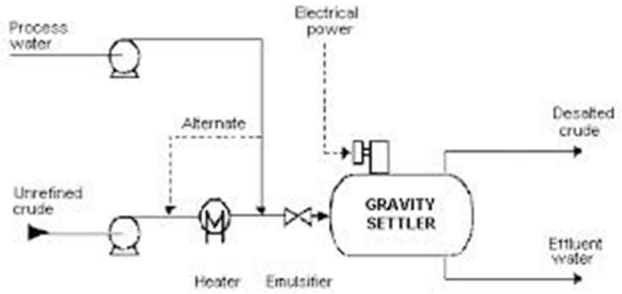
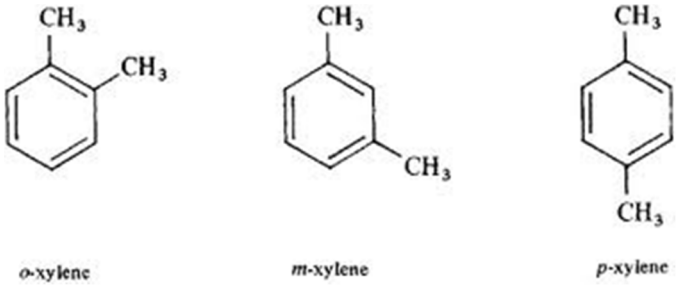
Model Answer

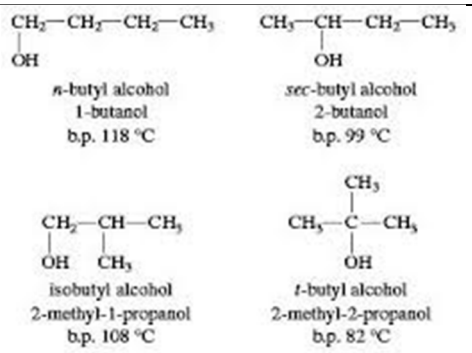
Subject &code : PCT(12299)

Important instructions to examiners :

1. The answers should be examined by keywords 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 given more importance.
4. While assessing figures, examiner may give credit for principal components indicated in a 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 answer and model answer.
6. In case of some questions credit may be given by judgment of relevant answer based on candidates understanding.

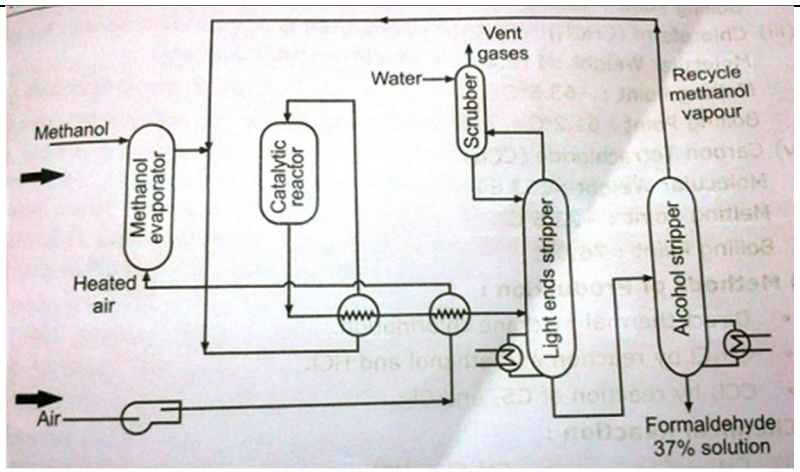
Q No:	**Answer**	**Mark**	**Total marks**
1.a.i	**2-**" A refinery is composed of a group of chemical engg.unit processes & unit operations used for refining certain materials or converting raw material into products of value". 1) IPCL,Baroda - 1.0 MMTPA 2) Reliance,Hazira - 1.6 MMTPA	2 2	4
1.a.ii	**Desalting**-Crude oil often contains water,inorganic salts,suspended solids & water soluble trace metals.As a first step in the refining process,to reduce corrosion, plugging, & fouling of equipment & to	2	4

	prevent poisoning the catalyst in processing units,these contaminants must be removed by desalting. Electrical Desalting-The feedstock crude oil is heated between 150^0F &350^0F to reduce viscosity & surface tension for easier mixing & separation of water . In electric desalting water & unrefined crude is heated & forms emulsion.This emulsion is break through electrical voltage for about 20000 to 30000 V .So the impurities in crude oil are seperated.  	2	
1.a.iii	Isomerization-is used to alter the arrangement of a molecule without adding or removing anything from the original molecule. **xylene**  *o*-xylene *m*-xylene *p*-xylene **Butyl alcohol**	2 1 1	4

			
1.a.iv	Primary treatment is the separation of oil, water, hydrocarbon & solids from waste water in two stages. During the first stage, an API separator, a corrugated plate intercepater or other separator design is used. Wastewater moves very slowly through the separator allowing free oil to float to the surface & be skimmed off & solids to settle to the bottom & be scraped off to a sludge collecting hopper. The second stage utilizes physical or chemical method to separate emulsified oils from the waste water. Physical method may include use of series of settling ponds with a long retention time or the use of dissolved air flotation(DAF).In this air is bubbled through the wastewater & both oil & suspended solids are skimmed off from the top.	2 2	4
1.a.v	**Propylene oxide**- for Between 60 and 70% of all propylene oxide is converted to polyether polyolsthe production of polyurethane plastics. About 20% of propylene oxide is hydrolyzed into propylene glycol, via a process which is accelerated by acid or base catalysis. Other major products are polypropylene glycol, propylene glycol ethers, and propylene carbonate. **Toluene**-solvents-paints,rubber,plastic cements,Detergents-toluene sulfonates **MTBE**-as afuel component in fuel for gasoline engines,as areaction	2 mark each for any two	4

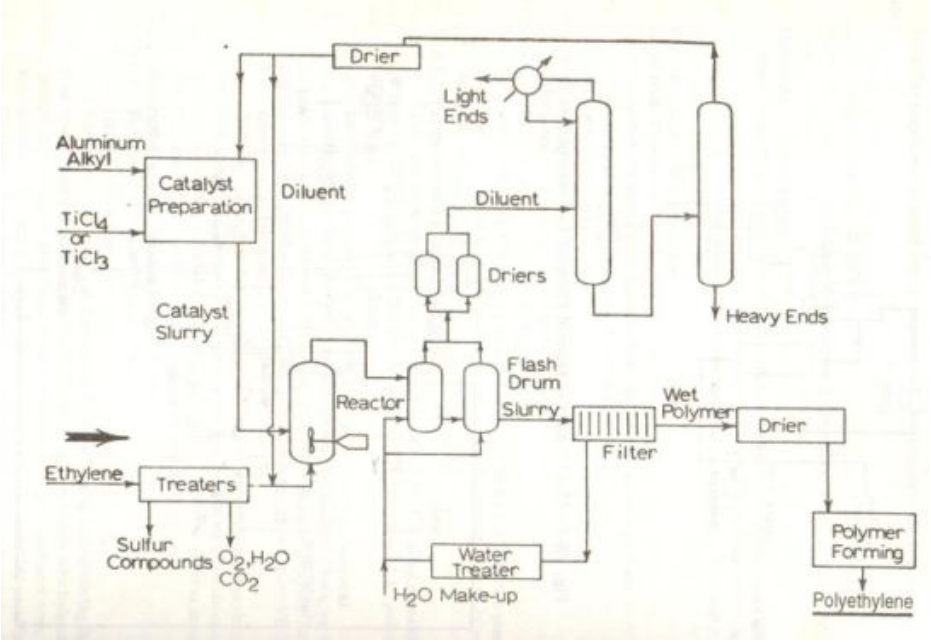
	medium & extraction solvent to replace methylene chloride,aromatics.		
1.b.i	Crude oil is the term for unprocessed oil, the stuff that comes out of the ground.It is also known as petroleum.Crude oil is a fossil fuel. Meaning that it was made naturally from decaying plants & animals living in ancient seas millions of years ago.Crude oils vary in colour,from clear to tar black, & in viscosity, from water to almost solid. Carbon -84% Hydrogen -14% Sulphur -1 to 3% Nitrogen - < 1% Oxygen - <1% Metals - < 1% Salts - <1%	3 3	6
1.b.ii	**Personal** –Hearing protection, respiratory protection, safety glasses **Vehicles** – Vehicle entry is by permit only & keys are to be left in park vehicles **Special authorization permits** –excavation, temporary electrical facilities **Electrical precautions** –All electrical tools ,cords & equipments must be grounded or double insulated. **Emergency warning system & procedure** –When an alarm sounds, secure all equipments & shut down all machines. **Sewers** –Sewers must be covered when hot work is being done in the vicinity.	1 mark each	6
2.a	Difference between petroleum refinery and petrochemical industry A refinery processes crude oil into different components such as kerosene, gasoline, diesel, LPG (light petroleum gases), etc. A	4	4

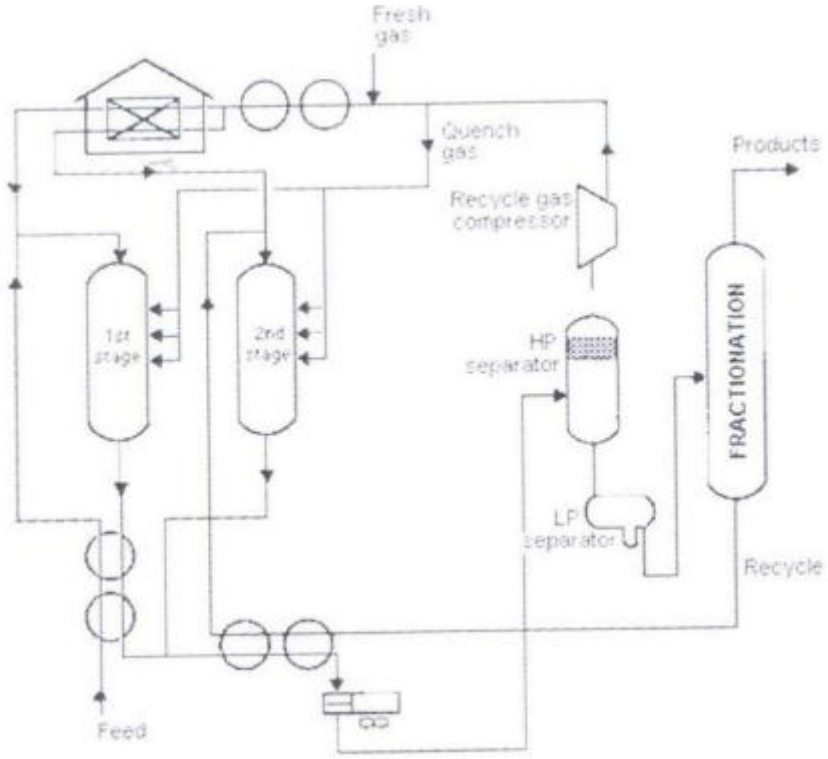
	petrochemical plant is a chemical plant that will use a petroleum based feedstock, such as LPG or other products from a petroleum refinery to produce a chemical product, such as plastics for example		
2.b	The crude oil distillation unit (CDU) is the first processing unit in virtually all petroleum refineries. The CDU distills the incoming crude oil into various fractions of different boiling ranges, each of which are then processed further in the other refinery processing units. Crude oil contains various constituents such as diesel, petrol, asphalt, waxes etc. So for efficient separation of all hydrocarbons distillation is very important.	4	4
2.c	Reforming –Catalytic reforming is an important process used to convert low octane napthas into high octane gasoline blending components called reformates. Reforming represents the total effect of numerous reactions such as cracking, polymerization, dehydrogenation & isomerisation taking place simultaneously. Depending on the properties of the naphtha feedstock & catalyst used ,reformates can be produce with very high conc. Of toluene, benzene, xylene &other aromatics useful in gasoline blending & petrochemical processing.	4	4
2.d	In secondary treatment, dissolved oil & other organic pollutants may be consumed biologically by microorganisms. Biological treatment may require addition of oxygen through a number of different techniques, including activated sludge units, trickling filters & rotating biological contactors. Secondary treatment generates biomass, waste which is typically treated anaerobically, & then dewatered. These processes biologically degrade and oxidize soluble organic matter by the use of activated sludge, aerated lagoons.	4	4

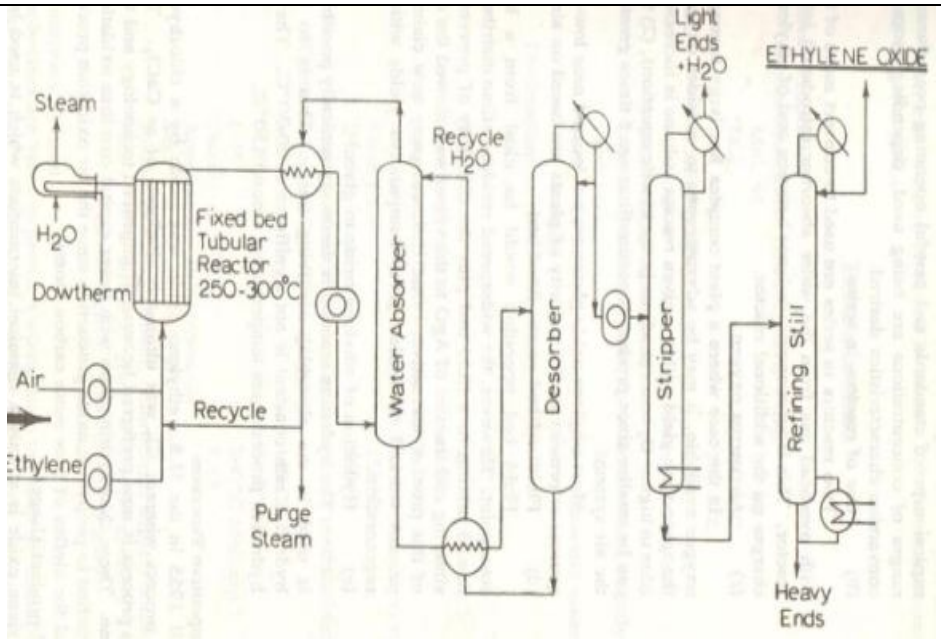
2.e		4	4
2.f	Flash point –It is the lowest temp. at which the oil gives of enough vapours which ignites for a moment when small flame is brought to near it. Auto ignition temperature – It is the temp. at which a substance can be brought to flames whitout any sort of external force, such as flame or spark. LEL –As a combustible gas is gradually mixed with air in increasing proportions, a conc. Is reached at which the mixture just becomes explosive i. e. ignitable. HEL –As conc. of the gas is further increased , a point is reached at which the mixture ceases to be ignitable,& the conc. of the gas just before this point is called higher explosive limit.	1 1 1 1	4
3.a	In fractional Distillation the mixture of multi components are separated into their parts by means of their relative volatility and Boiling points. Especially when their boiling points are 25 ^{O}C less with each other. This operation is carried out in Fractional column known as Fractional Distillation. Examples: 1) Crude Oil Distillation 2) Argon is produced industrially by the <u>fractional distillation</u> of <u>liquid air</u> 3) Oxygen and Nitrogen separation	2 2	4

	Etc.		
3.b	**i) Naphtha** As a feedstock for ethylene and aromatic production, for gasoline production by reforming or isomerisation etc **ii) Diesel oil** Fuel for furnace boilers, in diesel engines **iii) Jet Fuel** Uses in aviation turbine power plant, Sometimes in diesel engines as resemble as a diesel oil iv) **Asphalt** For road Construction as a binder, for Building construction, making asphalt tires	1 mark each	4
3.c	Emission contains saturated HC usually in the lower molecular weight range. The emission come from venting excess associated gas & from evaporative losses in water treatment facilities, pump & storage tank. In addition there exists a higher potential for accidents, therefore an increased possibility of spillage. 1) Hydrocarbon emission controls This can be minimized by process changes installation of control equipments & improved housekeeping. 2) Combustion source controls Hydrocarbon emissions from process heaters & steam boilers can be minimized by adjusting the fuel to air ration for optimum fuel combustion 3) Storage & loading controls. 4) Loading rule controls. 5) Process source controls. 1) Incineration In brief existing control technology for production emission consist of the following Storage facilities	4	4

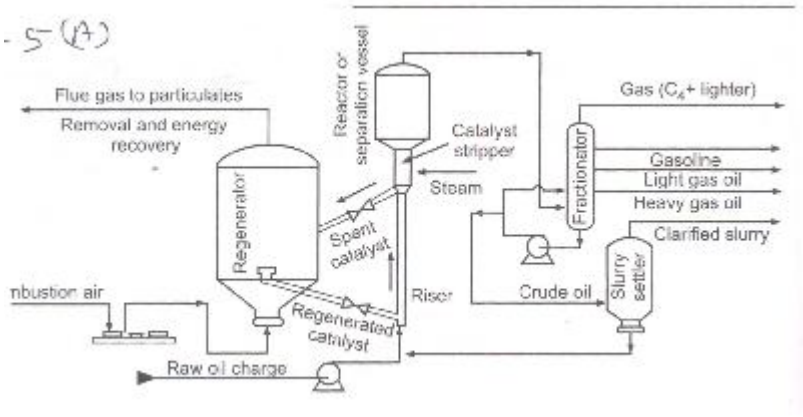
	Wastewater separators Pump & compressor seals Relief valves Pipeline valves Heaters & compressor engines & other losses.		
3.d	i) 1)Absolute Alcohol : The 100% alcohol which is made by adding ternary azeotrop like benzene or extractive distillation using ethylene glycol is known as 100% alcohol or absolute alcohol. 2) Rectified Spirit: This is 95% ethanol taken off from rectifying column and used a direct sale as potable, government controlled alcohol known as Rectifying Spirit. ii) Denatured alcohol or methylated spirits is ethanol that has additives to make it undrinkable (poisonous, extremely bad tasting, foul smelling or nauseating), to discourage recreational consumption. e.g Methanol, Iso propyl alcohol, methyl ethyl ketone, acetone	1 1 1 1	4
3.e	$C_6H_6 + CH_2=CH_2 \longrightarrow C_6H_5CH_2CH_3$ $C_6H_5CH_2CH_3 + H_2 \longrightarrow C_6H_5CHCH_2$ Temperature: 200 to 500 OC Catalyst ALCl3, Promoted Zinc, Cr, Fe or MgO on activated carbon Uses : In the production of SBR In packaging Industries, In rubber, plastic, insulation, Polymer	1 1 2	4
4.a.i	Crude oil is a yellowish black mineral oil that is extracted from under the surface of earth. This oil consist of a no. of hydrocarbon compounds as it is from the million of year old animal & plant .crude oil the single most important commodity that holds the position of a key factor in each &every economy of the world .The world richest nation are at their current position fast because of the oil factor. The imp. Of oil has reached such a level at which these is no country in the world. Crude oil over other energy sources: 1)Diverse application	4	4

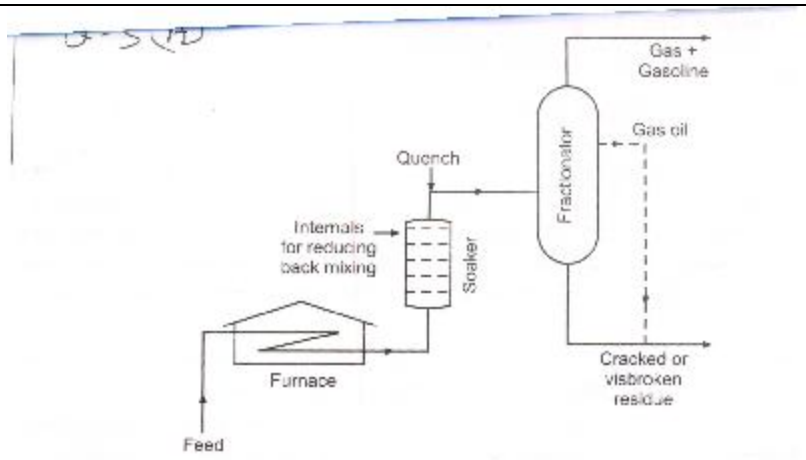
	2)comparatively user harm to environment 3)Easy handling 4) Lower capital Cost Above all higher efficiency.		
4.a.ii	 OR 1) Addition polymerization is addition of monomers to produces only a saturated polymer molecule 2) Monomers are unsaturated 3) Polymers are hard to degrade and non recyclable 4) <u>polyethylene</u>, <u>polypropylene</u>, and <u>polyvinyl chloride</u> 5) It is rapid process 1) In condensation polymerization functional group of two monomers reacts together releasing one small molecules and polymers. 2) Monomers are saturated 3) Polymers are easy to degrade and recyclable as compared to addition polymerization. 4) <u>poly</u>peptides, <u>poly</u>ester It is slow process as compared to addition polymerization.	4 1 mark each	4

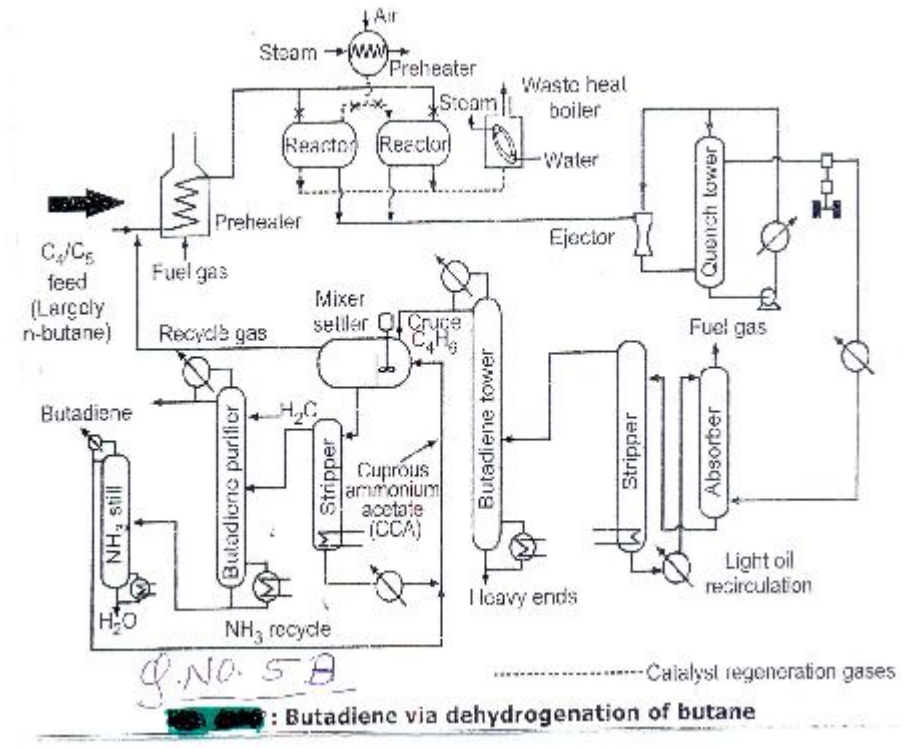
4.a.iii	Hydro cracking is the two stage process combining catalytic cracking & by hydrogenation where in feedstock are cracked into pressure of hydrogen to produce or desirable products. The process employs high pressure high temp. a catalyst & hydrogen .Hydro-cracking is used for feedstock that are difficult to process by either catalytic cracking are reforming.  	2 2	4
4.a.iv			4

<table>
<tr><td></td><td> 
</td><td>4</td><td></td></tr>
<tr><td>4.b.i</td><td><table>
<tr><td>Distillation fraction</td><td>Boiling point(^{0}C)</td></tr>
<tr><td>Gases</td><td>Below 30</td></tr>
<tr><td>Gasoline</td><td>30-210</td></tr>
<tr><td>Naphtha</td><td>100-200</td></tr>
<tr><td>Kerosene and jet fuel</td><td>150-250</td></tr>
<tr><td>Diesel and fuel oil</td><td>160-400</td></tr>
<tr><td>Atmospheric gas oil</td><td>220-345</td></tr>
<tr><td>Heavy fuel oil</td><td>315-540</td></tr>
<tr><td>Atmospheric residue</td><td>Over 450</td></tr>
<tr><td>Vacuum residue</td><td>Over 615</td></tr>
</table></td><td>4</td><td>6</td></tr>
<tr><td>4.b.ii</td><td>Description:
Udex process: Reformate as a feed can be send to the extraction column at a temp. Of 140-150^{0}C. During extraction we get two phases extract & raffinate. Extract contain aromatic compound while raffinate contain non aromatic compound. Solvent used to extract aromatic compound from reformate feed & send to stripper column , in which solvent</td><td>4</td><td>6</td></tr>
</table>

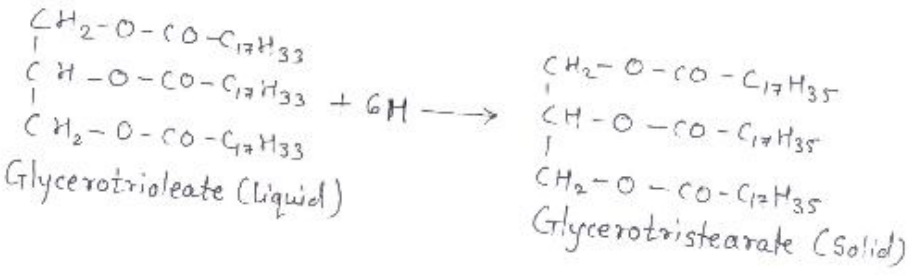
	removed from bottom & aromatic from top. It is cooled and to settler. Two settler are used one settler is feed back again to extraction column as a reflux which about 1-1.5% volume of feed. Remaining part is fed to wash water where the impurity is removed. Top as a product contain 99% benzene & 96% xylene. **products from Xylene** : 1) phthalic Anhydride 2) Isophthalic Acid 3) Dimethyl terephthalate	2	
5.a	The principal aim of catalytic cracking is to crack lower value stocks and produce higher value light and middle distillates. The process produces light hydrocarbon gases, which are important feed stocks for petrochemicals. catalytic cracking produces more gasoline of higher octane than thermal cracking. Products from catalytic cracking unites are more stable due to a lower olefin content in the liquid products. A major difference between thermal and catalytic cracking is that reactions through catalytic cracking occur via carbonation intermediate, compared to the free radical intermediate in thermal cracking. catalytic cracking is similar to thermal cracking except that catalysts facilitate the conversion of the heavier molecules into lighter products. Use of a catalyst in the cracking reaction increases the yield of improved quality products under much less severe operating condition than in thermal cracking. The three types of catalytic cracking processes are 1) fluid catalytic cracking 2) moving bed catalytic cracking 3) thermoform catalytic cracking. **Fluid catalytic cracking:-**	4	8

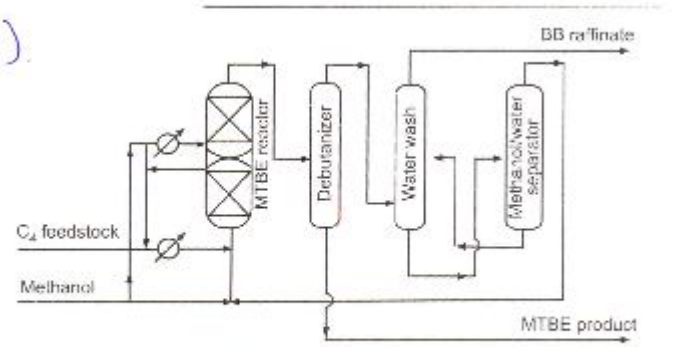
	The fluid cracker consists of a catalyst section and a fractionating section that operate together as an integrated processing unit. the oil is cracked in the presence of a finely divided catalyst.  In **thermal cracking** distillate fuels and heavy oils were heated under pressure in large drums until they are cracked into smaller molecules with better antiknock characteristics. However this method produces large amounts of solid, unwanted coke. types of catalytic cracking processes are 1) visbreaking 2) steam cracking 3) coking. **Visbreaking:-** Residual from the atmospheric distillation tower is heated and mildly cracked in a heater. It is then quenched with cool gas oil to control over cracking and flashed in a distillation tower. visbreaking is used to reduce the pour point of waxy residues and reduce the viscosity of residues used for blending with lighter fule oil	4	

			
5.b	**Process description:-** A refinery gas of C4 / C5 cut is mixed with recycle gas and preheated to reaction temp prior to contact with a catalyst in a fixed bed , regenerative heating system. The product gases from reactor system are oil quenched, compressed, cooled and separated from the light ends by absorption in naphtha followed by stripping. The overhead is fractionated to yield crude butadiene at the top which is purified by 1) absorption using cuprous ammonium acetate 2)extractive distillation with furfural ,or 3) azeotropic distillation with ammonia. The more common absorption process involves contact of the close boiling butadiene-butane fraction with lean (CAA) cuprous ammonium acetate solution with dissolves butadiene. A desorption step at higher temp is followed by distillation, compression and liquefaction of butadiene to give 98.99% product purity. **Flow dig:-**	4 4	8

			
5.c	i) Hazards:- A **hazard** is a situation that poses a level of threat to life, health, property, or environment. Most hazards are dormant or potential, with only a theoretical risk of harm. Hazards chemicals:- chemicals used ,handled or stored in a factory, which are toxic, corrosive or flammable, are called Hazards chemicals. ii) Types of hazardous in petrochemical industry:- 1. Atmospheric hazards:-due to lack of oxygen level 2. Chemicals hazards:-due to any hazardous type chemicals in the form of solids, liquids , gases, mists, dust, fumes & vapours exert toxic effects on inhalation, absorption or ingestion. 3. Biological hazards:- these include bacteria , viruses, fungi and other living organisms that can cause acute & chromic infection by entering the body either directly or through breaks in the skin. 4. Physical hazards :-these include excessive levels of ionizing and non-ionizing electromagnetic radiation,noise,vibration & temp.	4 4	8

	5. Ergonomic hazards: - these include excessive vibration and noise, eye strain, repetitive motion, and heavy lifting problem, improperly designed tools or work areas.		
6.a	Advantages of vacuum distillation compared to atm. Distillation are as follows:- Vacuum distillation is used for compounds that have high boiling points (usually above 200 °C). These compounds tend to decompose at the boiling point temp required at atmospheric pressure. Since pulling a vacuum on the flask will reduce the temperature required to have boiling you avoid decomposition. Heavier fractions from the atmospheric distillation unit that cannot be distilled without cracking under its pressure and temp conditions are vacuum distilled. Vacuum distillation is simply the distillation of petroleum fractions at very low pressure to increase volatilization and separation. Vacuum distillation increases the relative volatility of the key components in many applications. The higher the relative volatility, the more separable are the two components; this connotes fewer stages in a distillation column in order to effect the same separation between the overhead and bottoms products. Lower pressures increase relative volatilities in most systems. Examples. Vacuum distillation is used to recover additional distillates from long residue in petroleum refinery Vacuum distillation is used in the manufacturing of phenol.	2 2	4
6.b	Hydrogenation reaction of unsaturated oil:-	1	4

	Q-6 B  Glycerotrioleate (Liquid) Glycerotristearate (Solid) Catalyst:- :- Nickel ,platinum, palladium, rhodium ,ruthenium 01 marks Temperature range:- 110^0C to 200^0C 01 marks Pressure:- 0.24lb 01 marks	1 1 1	
6.c	Characteristic of waste water produced in refinery from **:** i) Crude oil desalting – crude oil or desalted sludge(iron,rust,clay,sand,water,emulsified oil and wax, metals) ii) Coking – coked dust (carbon particles and hydrocarbons) iii) Catalytic cracking – spent catalyst iv) Heat ex changer cleaning – heat exchanger sludge (oil, metals & suspended solid) v) Storage tank – tank bottom sludge (iron,rust,clay,sand,water,emulsified oil and wax, metals)	1 mark each, any four	4
6.d	**Chemical reaction**:- i) Main reaction:- C6H6 + CH3.CH=CH2 → C6H6.C3H7 [isopropyl benzene(cumene)] ii) Side reaction:- C6H6 + nCH3.CH=CH2 → C6H6-n.(C3H7)n polyisopropyl benzene	1	4

	Temperature: 250^0C **Catalyst**: Impregnated H3PO4 **Process description:-** Propylene – propane feedstock from refinery off-gases of a naphtha steam cracking plant is mixed with benzene and pumped at 25 atms. Into the top of the reactor ,packed stage wise with H3PO4 impregnated catalyst. The temp is maintained at approximately 250^0C by adding cold propane at each stage to absorb the heat of reaction. The reaction effluent is depropanized and the propane split into quench or product streams. The depropanized bottoms are separated into benzene, cumene, & polycumenes in the remaining two stills.	1 2	
6.e	**Flow dig:-** Q6. e)  Fig. 4.17 : MTBE via catalytic etherification **Process Description :**	4	4