MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

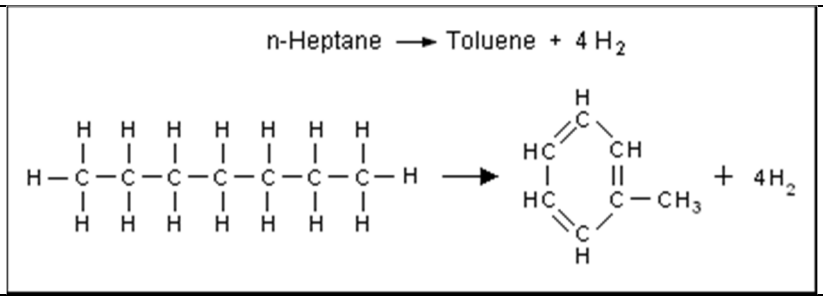
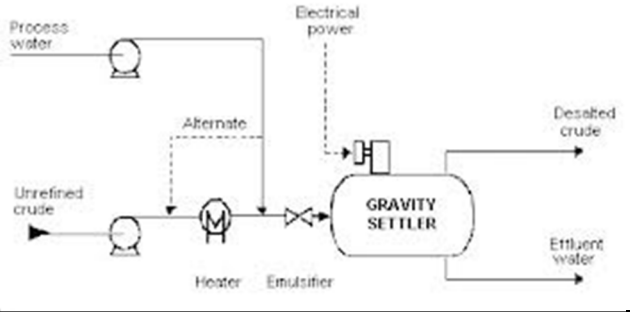
WINTER-12 EXAMINATION

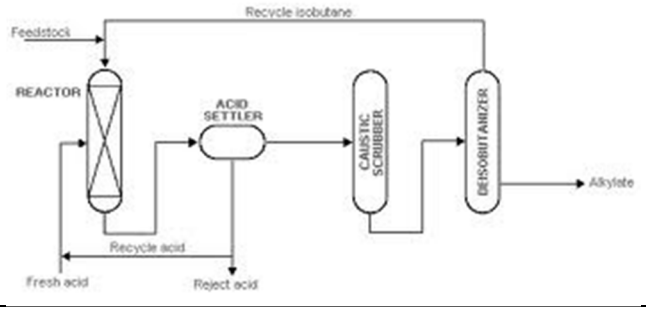
Model Answer

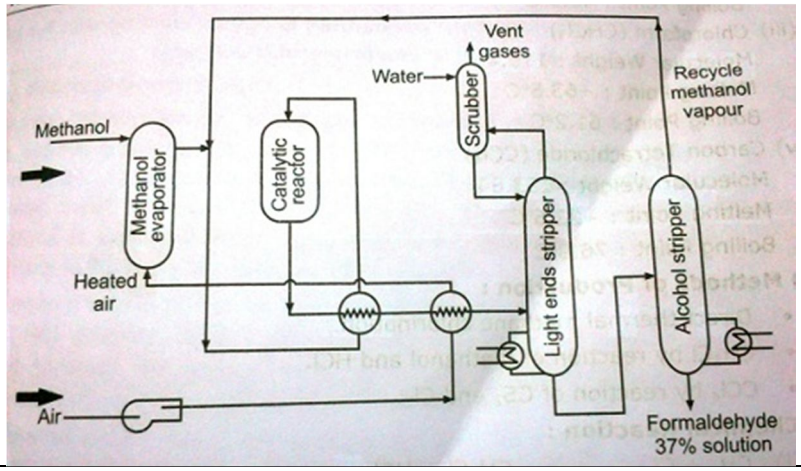
Subject code: PCT (12299)

Q. No	Answer	Remarks
1-A a)	OPEC-organization of petroleum exporting countries 1)Saudi Arabia-8.73 million barrels per day 2)Iran-2.55 million barrels per day 3)Kuwait-2.20 million barrels per day 4)Iraq-1.48 million barrels per day 5)Venezuela-2.36million barrels per day 6)Algeria-1.68 million barrels per day	1 mark ½ mark each
b)	i) Natural gas-: Uses- As a fuel ii) Petroleum gases-: LPG for Cooking. iii) Gas oil-: To make diesel fuel. iv) Kerosene-: For cooking & heating installations v) Diesel oil-: Used in ships , Locomotives, Buses	2 marks for fractions and 2 marks for uses
c)	Two Types of cracking process-1)Thermal cracking 2)Catalytic cracking Difference-In case of thermal cracking,temp is used for cracking & in catalytic cracking catalyst also used.Products of catalytic cracking are more stable than thermal cracking.	2 marks 2 marks
d)	) Hat ii) Safety goggles iii) Acid proof hoods	4 marks

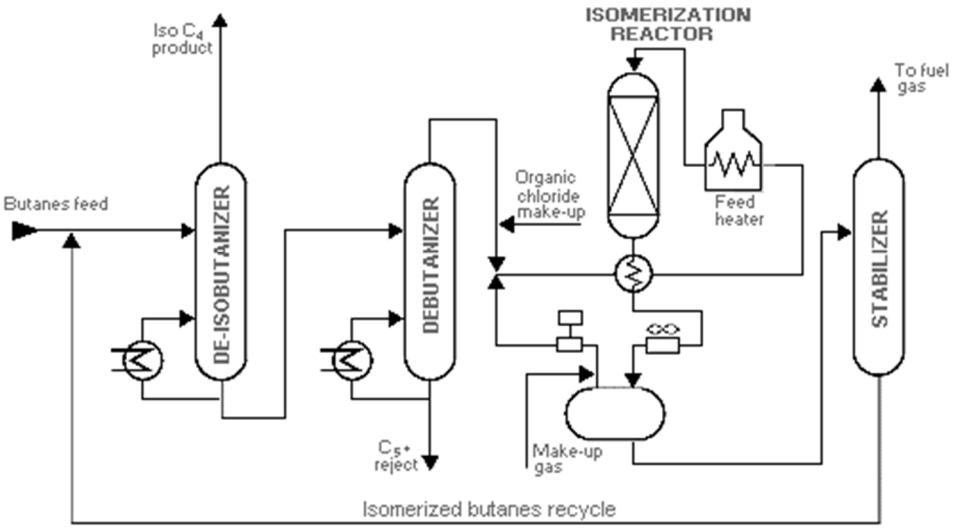
	iv) Face shield v) Gloves vi) non- conducting shoes	
1-B a)	**Constituents-:** i)Paraffins ii)Aromatics iii) Napthenes iv) dienes **Characterstics-:** Yellowish black oily, Complex mixtures May be low viscocity or highly viscous **Unit operations-:** i)Desalting ii)Fractional distillation iii) Solvent extraction iv) Solvent extraction	2 marks 2 marks 2 marks
b)	**Principle-:** Reforming Is used to convert Hydrocarbons to aromatics which have high octane rating. **Uses-:** Catalytic reformates make excellent blending stocks. Boiling point range is broader. So used in making good cold wheather petol. To supply aromatic feedstocks for petrochemical industry **Reactions-:**	2 marks 2 marks

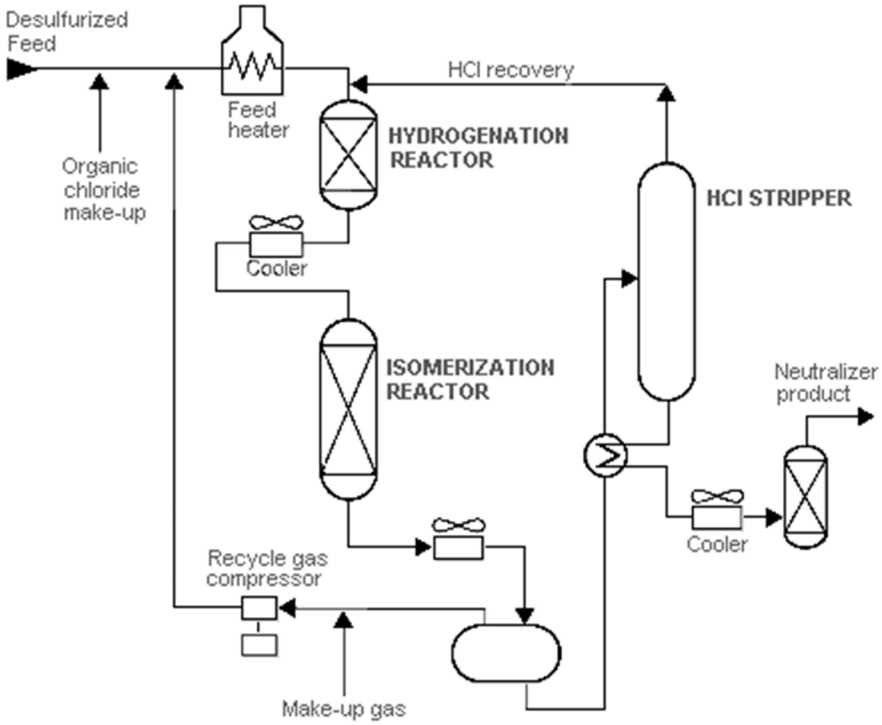
		2 marks
2- a)	**Description-:** To reduce corrosion,plugging & to prvent poisoning catalyst in processing units desalting is used.Electrical desalting applications of high voltage electrostatic charges to concentrate suspended water globules in the bottom of the settling tank.Surfactants are added only when the crude has a large amount of suspended solids Method is continuous.The feedstock crude is heated between 150^0 & 350^0F to reduce viscosity & surface tension for easier mixing & separation of the water.The desalted crude is continuously drawn from the top of settling tanks & sent to the crude distillation tower. 	2 marks 2 marks
b)	**Description-** Two methods of alkylation 1) sulphuric acid alkylation 2)Hydrofluoric acid alkylation Sulfuric acid alkylation-In cascade type sulphuric acid alkylation the feedstock (propylene,butylene) enters the reactor & contacts the sulphuric acid catalyst .The reactor is divided into zones ,with olefins fed through distributors to each zone & the sulphuric acid & isobutanes flowing over baffles from zone to zone.the reactor effluent is separated into hydrocarbon & acid phase in a settler & the acid is return to the reactor.The alkylate obtained from the deisobutanizer can then go directly to motor fuel blending.The isobutene is recycled to the feed.	2 marks

	c | c-c-c+c=c-c--→c-c-c-c-c | | | | C c c c i-butane i-butene 2,2,4 trimethyl pentane  	2 marks
c)	1)catalytic cracking produces more gasoline of higher octane than thermal cracking. 2)Products of catalytic cracking are more stable due to a lower olefin content in the liquid products. 3)Reactions through catalytic cracking occurs via carbocation intermediates,compared to free radical intermediates in thermal cracking. 4)Carbocations are longer lived & accordingly more selective than free radicals.	1 mark each
d)	1)Reliance,Hazira-1.6 MMTPA 2)IPCL,Baroda-1.0MMTPA 3)HPCL,Mumbai-0.43 MMTPA 4)NOCIL,Thane-0.30 MMTPA	1 mark each
e)	1)Desalting-high level of suspended solids,high BOD,high temp. 2)Atmospheric/Vaccum distillation-H_2S,phenol, dissolved solids,chlorides,mercaptants,elevated pH. 3)Cocking-cod,high pH,H_2S,NH_3. 4)Catalytic cracking-High level of oil,cyanides,BOD,COD. 5)Storage Tank-Water drained from tanks contaminated with tank product.	1 mark each

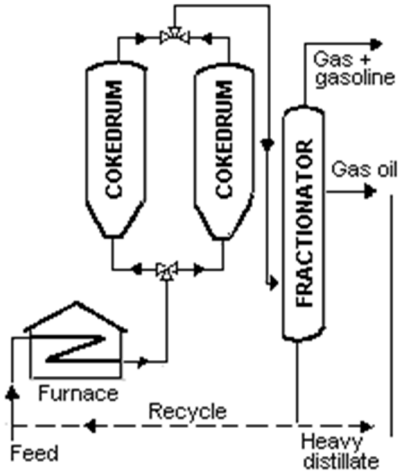
f)	**Formaldehyde from methanol**  	4 marks
3- a)	**i) <u>Jet Fuel:</u>** a) use in aviation turbine power units b) *Jet fuel* is very similar to Diesel fuel, and in some cases, may be burned in Diesel engines **ii) <u>Naphtha:</u>** a) Naphtha is a feedstock destined either for the petrochemical industry (e.g. ethylene manufacture or aromatics production). b) For gasoline production by reforming or isomerisation within the refinery. **iii) <u>Motor Gasoline:</u>** a) Normally used as a fuel for spark ignition internal combustion engines such as passenger cars, 2 wheelers, 3 wheelers etc. b)It is used in internal combustion engine **a) <u>Aviation Gasoline:</u>** **a)** for aviation piston engines **b)** Used in internal combustion aircraft engines with spark ignition (piston) engines.	1 mark 1 mark 1 mark 1 mark
b)	**<u>Polymerization:</u>** Polymerization in the petroleum industry is the process of converting light olefin gases including ethylene, propylene, and butylene into hydrocarbons of higher molecular weight and higher octane number that can be used as gasoline blending stocks. Polymerization combines two or more identical olefin molecules to form a single molecule with the same elements in the same proportions as the original molecules. Polymerization may be accomplished thermally or in the presence of a catalyst at lower temperatures. **<u>Uses:</u>** **1.** To convert light olefin gases including ethylene, propylene, and butylene	2 marks

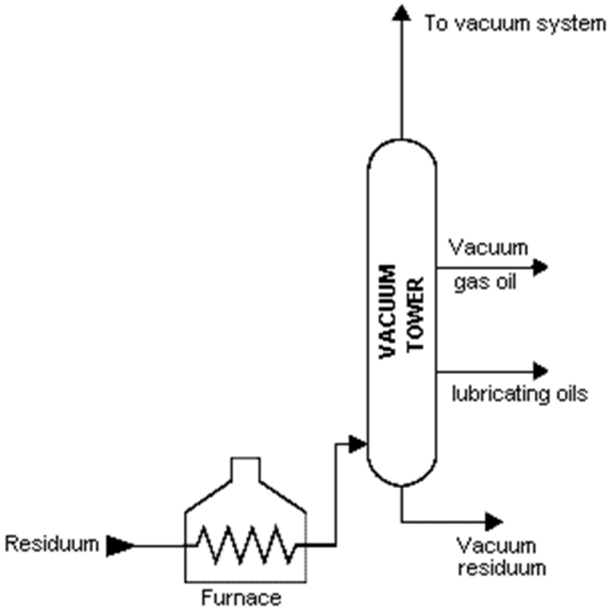
	into hydrocarbons of higher molecular weight and higher octane number that can be used as gasoline blending stocks. **Product Obtain:** 1. High octane naphtha. 2. Petrochemical feedstock. 3. Liquefied petro. gas **Reforming:** Catalytic reforming is an important process used to convert low-octane naphthas into high-octane gasoline blending components called reformates. Reforming represents the total effect of numerous reactions such as cracking, polymerization, dehydrogenation, and isomerization taking place simultaneously. **Uses:** 1. used to convert low-octane naphthas into high-octane gasoline blending components. **Product Obtain:** 1. High octane gasoline 2. Aromatics 3. Hydrogen 4. Gases	2 marks
c)	**Refinery:** A **refinery** is a production facility composed of a group of chemical engineering unit processes and unit operations refining certain materials or converting raw material into products of value. Different types of refineries are as follows: • oil refinery, which converts crude oil into high-octane motor fuel (gasoline/petrol), diesel oil, liquefied petroleum gases (LPG), jet aircraft fuel, kerosene, heating fuel oils, lubricating oils, asphalt and petroleum coke; • sugar refinery, which converts sugar cane and sugar beets into crystallized sugar and sugar syrups; • natural gas processing plant, which purifies and converts raw natural gas into residential, commercial and industrial fuel gas, and also recovers natural gas liquids (NGL) such as ethane, propane, butanes and pentanes; • salt refsolar evaporation of sea water, followed by washing and re-crystallization; • metal refineries refining metals such as alumina, copper, gold, lead,	1 mark 3 marks

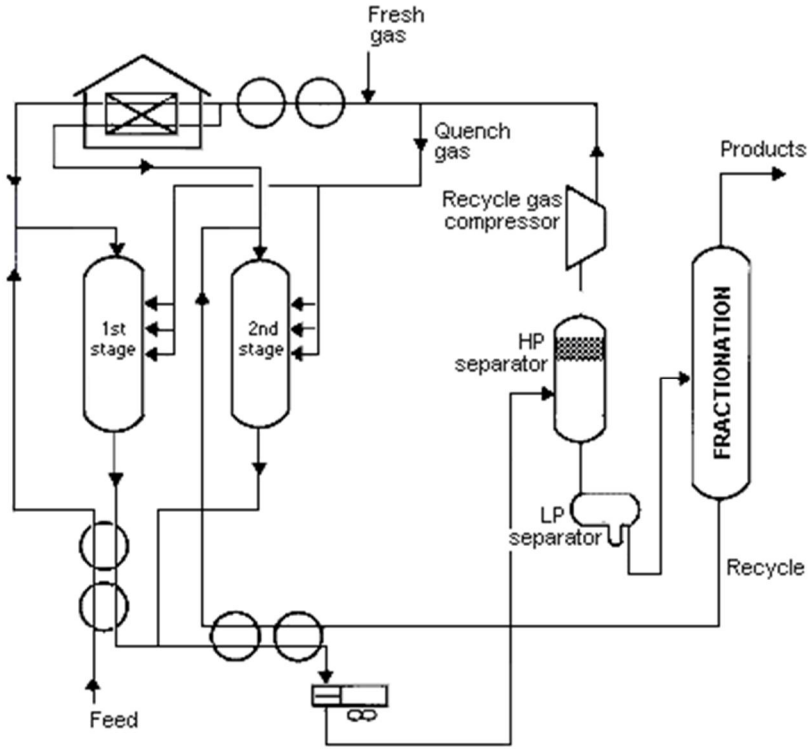
	nickel, silver, uranium, zinc, magnesium and cobalt; • vegetable oil refinery	
d)	**Isomerization:** I) butane (C_4) isomerization process  There are two distinct isomerization processes, butane (C_4) and pentane/hexane (C_5/C_6). Butane isomerization produces feedstock for alkylation. Aluminum chloride catalyst plus hydrogen chloride are universally used for the low-temperature processes. Platinum or another metal catalyst is used for the higher-temperature processes. In a typical low-temperature process, the feed to the isomerization plant is n-butane or mixed butanes mixed with hydrogen (to inhibit olefin formation) and passed to the reactor at 230°-340° F and 200-300 psi. Hydrogen is flashed off in a high-pressure separator and the hydrogen chloride removed in a stripper column. The resultant butane mixture is sent to a fractionator (deisobutanizer) to separate n-butane from the isobutane product. **OR** II) **pentane/hexane (C_5/C_6) isomerization process:**	2 marks 2 marks

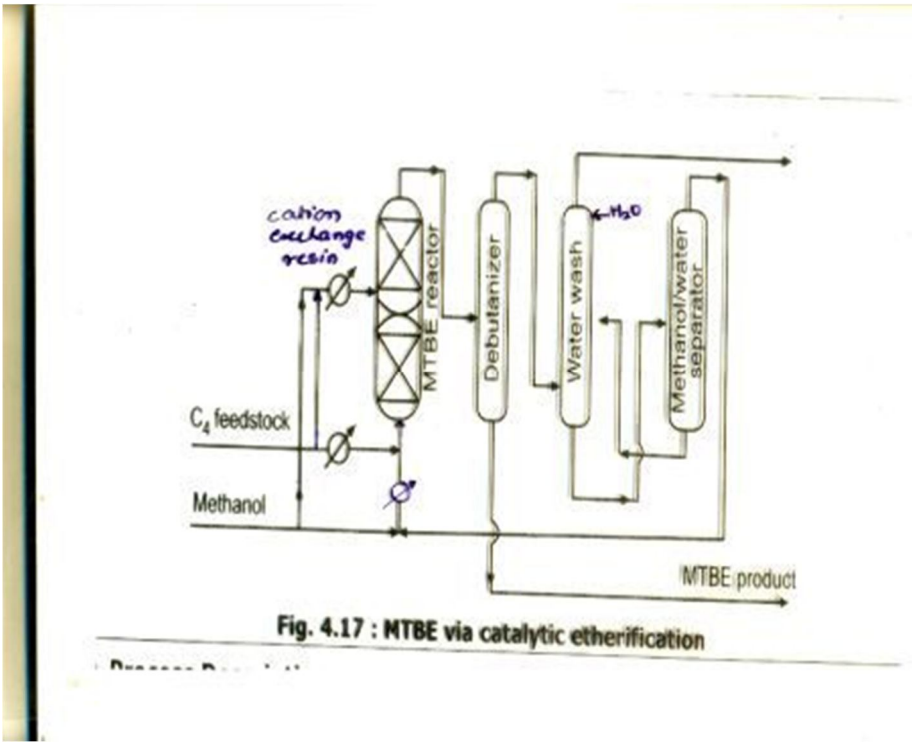


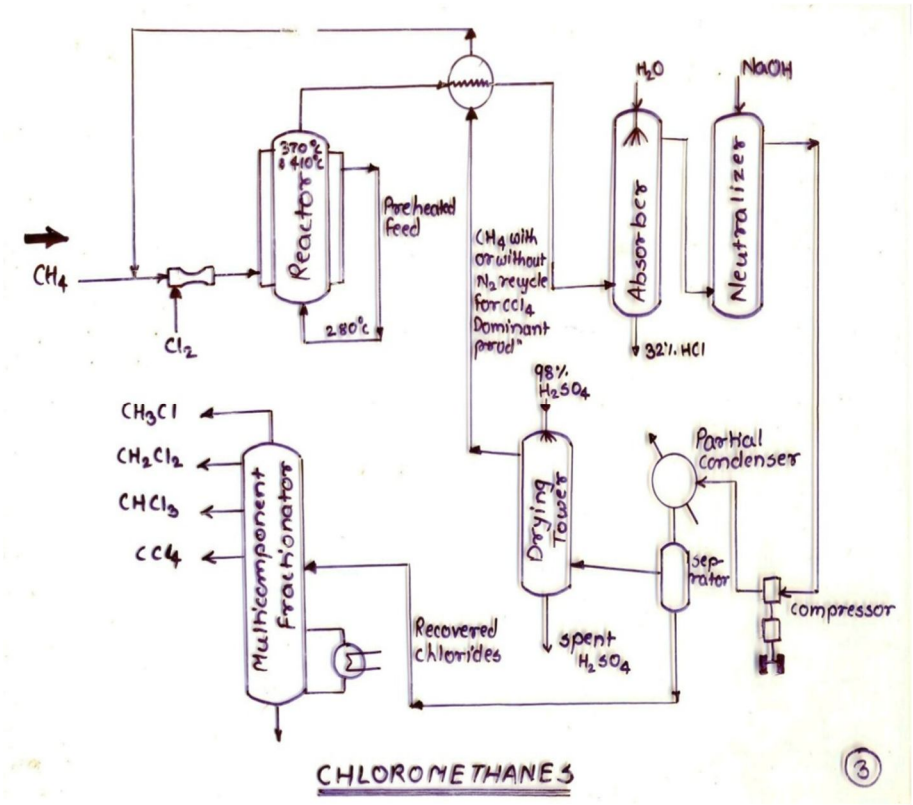
Pentane/hexane isomerization increases the octane number of the light gasoline components n-pentane and n-hexane, which are found in abundance in straight-run gasoline. In a typical C_5/C_6 isomerization process, dried and desulfurized feedstock is mixed with a small amount of organic chloride and recycled hydrogen, and then heated to reactor temperature. It is then passed over supported-metal catalyst in the first reactor where benzene and olefins are hydrogenated. The feed next goes to the isomerization reactor where the paraffins are catalytically isomerized to isoparaffins. The reactor effluent is then cooled and subsequently separated in the product separator into two streams: a liquid product (isomerate) and a recycle hydrogen-gas stream. The isomerate is washed (caustic and water), acid stripped, and stabilized before going to storage

e)	**Delayed Coking**  In delayed coking the heated charge (typically residuum from atmospheric distillation towers) is transferred to large coke drums which provide the long residence time needed to allow the cracking reactions to proceed to completion. Initially the heavy feedstock is fed to a furnace which heats the residuum to high temperatures (900°-950° F) at low pressures (25-30 psi) and is designed and controlled to prevent premature coking in the heater tubes. The mixture is passed from the heater to one or more coker drums where the hot material is held approximately 24 hours (delayed) at pressures of 25-75 psi, until it cracks into lighter products. Vapors from the drums are returned to a fractionator where gas, naphtha, and gas oils are separated out. The heavier hydrocarbons produced in the fractionator are recycled through the furnace. After the coke reaches a predetermined level in one drum, the flow is diverted to another drum to maintain continuous operation. The full drum is steamed to strip out uncracked hydrocarbons, cooled by water injection, and decoked by mechanical or hydraulic methods. The coke is mechanically removed by an auger rising from the bottom of the drum. Hydraulic decoking consists of fracturing the coke bed with high-pressure water ejected from a rotating cutter.	2 marks 2 marks
4-A a)	**Vacuum Distillation** Vacuum Distillation Tower. In order to further distill the residuum or topped crude from the atmospheric tower at higher temperatures, reduced pressure is required to	2 marks

	prevent thermal cracking. The process takes place in one or more vacuum distillation towers. The principles of vacuum distillation resemble those of fractional distillation and, except that larger-diameter columns are used to maintain comparable vapor velocities at the reduced pressures, the equipment is also similar. The internal designs of some vacuum towers are different from atmospheric towers in that random packing and demister pads are used instead of trays. A typical first-phase vacuum tower may produce gas oils, lubricating-oil base stocks, and heavy residual for propane deasphalting. A second-phase tower operating at lower vacuum may distill surplus residuum from the atmospheric tower, which is not used for lube-stock processing, and surplus residuum from the first vacuum tower not used for deasphalting. Vacuum towers are typically used to separate catalytic cracking feedstock from surplus residuum.  	2 marks
b)	**Air Pollutant:** 1) Hydrocarbon vapour 2) Sulphur dioxide 3) Carbon monoxide 4) Nitrogen Dioxide 5) Hydrogen sulphide 6) Chlorine 7) Ammonia 8) Catalyst dust **Water pollutant:** 1) Oil 2) Phenol 3) Heavy Metal	2 marks 2 marks

	4) H2S 5) NH3 6) Suspended solid 7) Dissolved solid 8) Spent catalyst	
c)	**Hydro cracking:** a. In the first stage, preheated feedstock is mixed with recycled hydrogen and sent to the first-stage reactor, where catalysts convert sulfur and nitrogen compounds to hydrogen sulfide and ammonia. Limited hydrocracking also occurs. b. After the hydrocarbon leaves the first stage, it is cooled and liquefied and run through a hydrocarbon separator. The hydrogen is recycled to the feedstock. The liquid is charged to a fractionator. Depending on the products desired (gasoline components, jet fuel, and gas oil), the fractionator is run to cut out some portion of the first stage reactor out-turn. Kerosene-range material can be taken as a separate side-draw product or included in the fractionator bottoms with the gas oil. c. The fractionator bottoms are again mixed with a hydrogen stream and charged to the second stage. Since this material has already been subjected to some hydrogenation, cracking, and reforming in the first stage, the operations of the second stage are more severe (higher temperatures and pressures). Like the outturn of the first stage, the second stage product is separated from the hydrogen and charged to the fractionator.  	2 marks 2 marks

d)	Process description  **Fig. 4.17 : MTBE via catalytic etherification**	2 marks 2 marks

4-B a)	Cholo methanes  Process description	3 marks 3 marks
b)	**Personnel** • Hearing protection and safety glasses must be worn in all operating areas or as posted. • Respiratory protection or equipment must be fittested. Facial hair is unacceptable where the mask must make an airtight seal against the face. • Shirts must be long-sleeved and worn with full-length pants or coveralls. • Clothing must not be of a flammable type such as nylon, Dacron, acrylic, or blends. Fire-resistant types include cotton, Nomex, and Proban. • Other PPE required may include acid hood, impervious outerwear, rubber boots, face shields, rubber gloves, disposable coveralls, monogoggles, and fall-arrest equipment. • Smoking is allowed only in designated areas.	6 marks

Vehicles

• Vehicle entry is by permit only and keys are to be left in parked vehicles.

• Vehicles must be shut down at the sound of any emergency alarm.

• Vehicles must be equipped with ground straps or cables.

or other testing must be repeated to

ensure a safe return to the work.

Electrical Precautions

• Electrical tagging and lockout **Permit Systems**

No work takes place in a refinery without a safe work permit. A safe work permit is a document issued by an authorized representative of the client permitting specific work for a

specific time in a specific area.Work permits should indicate the date and time of issue, the time of expiry, a description of the work to be done, and the name of the company performing the work. Permits also specify any hazards and controlled products underWHMIS and any protective equipment needed for the job. The permit will advise you of any steps required to make the area or equipment safe for work, tell you the results of any gas tests, advise you of any electrical lockouts that have been done, and tell you of any work practices required for the specific job. Safe work permits are valid only for a limited time and **must be renewed** following expiry or normally after any one-hour stoppage, after an emergency warning on the site, or for other safety reasons. After such an event, anyrequired gas testing procedures must be tagging and lockout procedures must be

understood and followed

Electrical Precautions

• Electrical by all workers.understood and followed by all workers.

• All electric tools, cords, and equipment must be

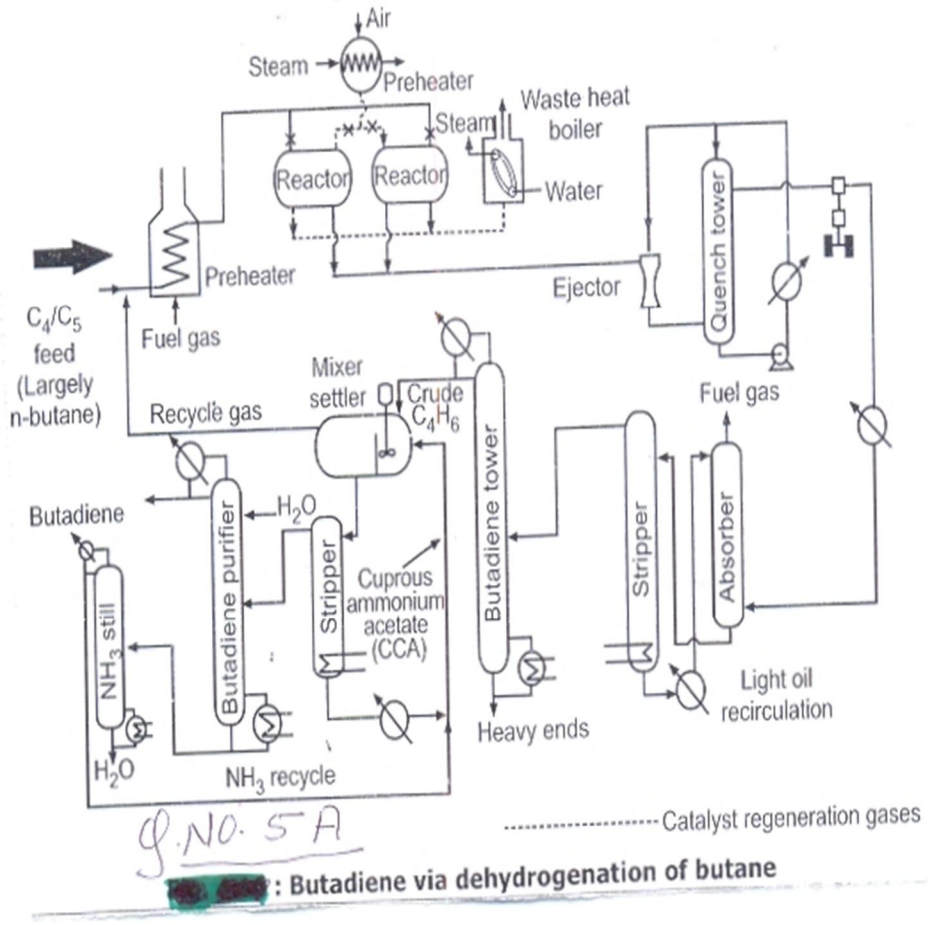
grounded or double-insulated.

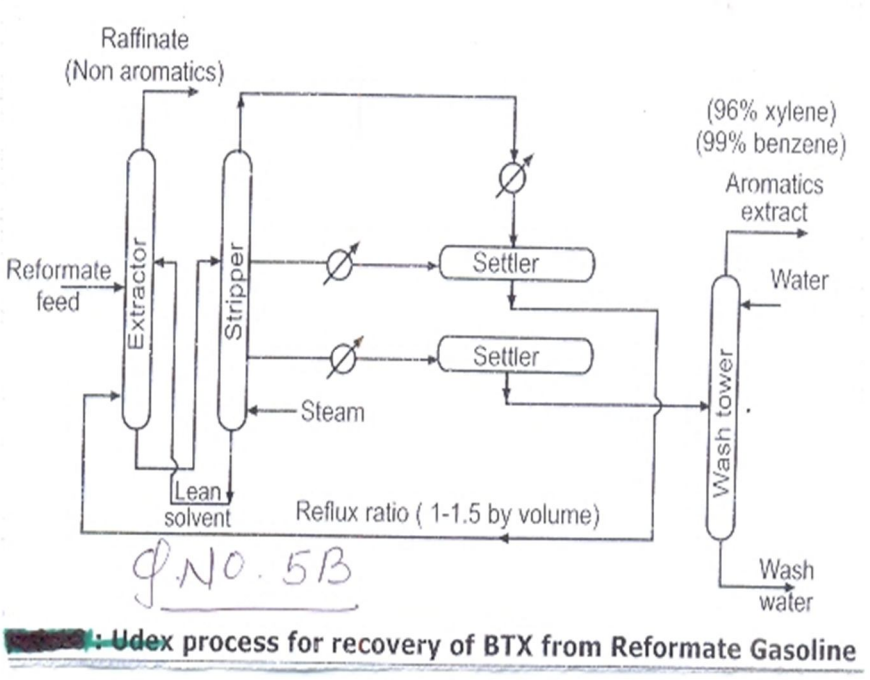
• Use explosion-proof fixtures where required.

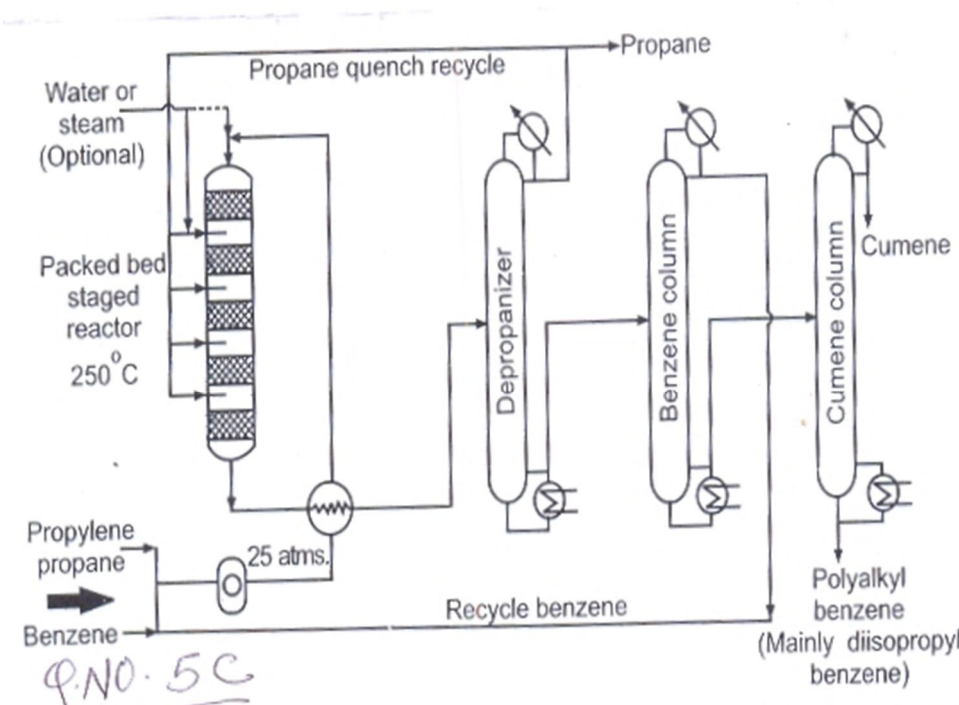
Sewers

• Sewers must be covered when hot work is being done

	in the vicinity. • Sewer covers must be in good condition with no openings for vapour flow. • Sewer covers are to be removed when hot work is discontinued at the end of the job or overnight to accommodate drainage. **Blinding or Blanking-off**	
5- a)	MAIN REACTION (i) $C_4H_{10} \rightarrow CH_2=CH.CH=CH_2+2H_2$ SIDE REACTION (ii) $C_4H_{10} \rightarrow C_6H_8+H_2$	1 mark 1 mark

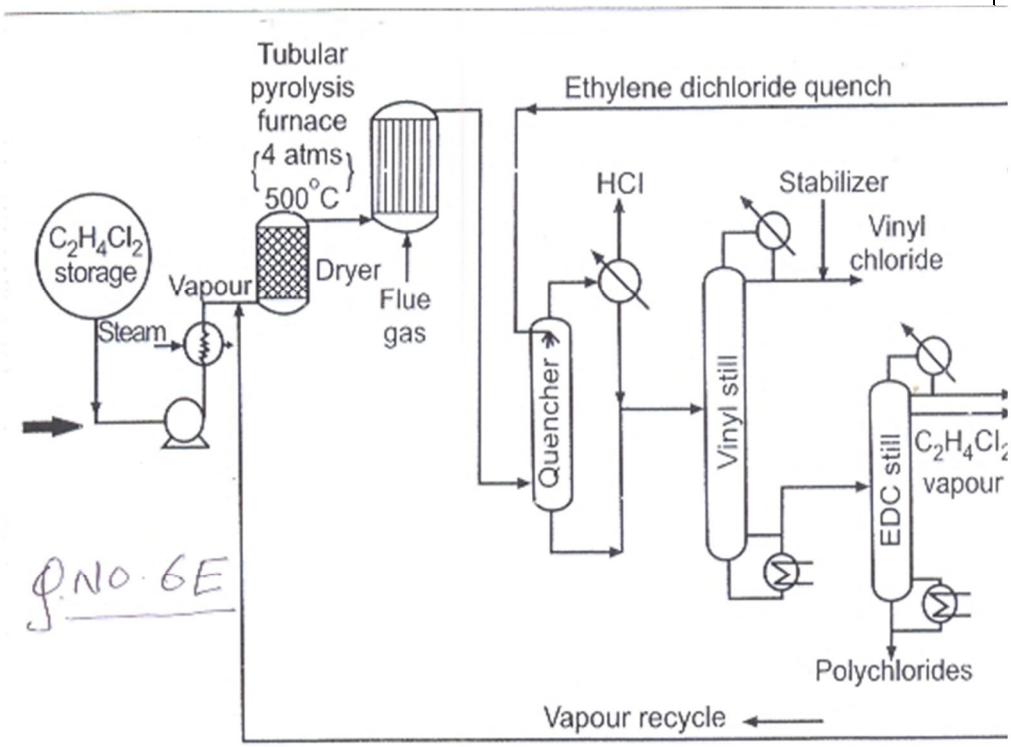
		5 marks
	USES (i) for production of Synthetic rubber (SBR) (ii) In petroleum refinery (ii) For fermentation of alcohol.	1 mark
b)	Udex process Reformate as a feed can be send to the extraction column at a temp. of 140-150 ^{0}c. During extraction we get two phases extract and raffinate.extract contain aromatic compound while raffinate contain non aromatic compound. Solvent used to extract aromatic compound from reformate feed and send to stripper column,in which solvent removed frombottom and 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% by volume of feed. Remaining part is fed to wash water where the	3 marks

	impurities are removed . Higher % of conc. aromatics extract component can be removed from top as a product contain 99% Benzene and 96% Xylene. DERIVATIVES FROM BTX—Benzene , Toluene , Xylene Diagram:-  Q.NO. 5B [redacted]: Udex process for recovery of BTX from Reformate Gasoline	2 marks 3 marks
c)	Cumene process Propylene-propane feedstock from refinery off-gases of a naphtha steam cracking plant is mixed with benzene and pump at 25 atm.in to top of reactor with H_3PO_4 catalyst. Temp. is 250^0C. Cold propane is added to absorb the heat of reaction. The reactor effluent is depropanised and the propane split in to quench or product streams. The depropanised bottoms are separated into benzene,cumene,and polycumenes in the remaining two still. Chemical reaction (i) Main reaction	3 marks 2 marks

	$C_6H_6+CH_3.CH=CH_2 \rightarrow C_6H_5.C_3H_7$ (ii) Side reaction $C_6H_6+nCH_3.CH=CH_2 \rightarrow C_6H_6\text{-}n.(C_3H_7)n$  Q.NO. 5C : Cumene (Isopropyl benzene) via propylene alkylation of benzene	3 marks
6- a)	A refinery processes crude oil into different components such as kerosene, gasoline, diesel, LPG (light petroleum gases), etc. A 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 marks 2 marks
b)	In today's modern society we have numerous uses for water both around the home as well as in commercial or industrial operations. This water becomes waste-water once it has been "used" - whether for washing dishes in a restaurant, flushing a toilet, or as part of a manufacturing process. Rainfall and runoff from streets and parking lots is also wastewater. These	4 marks

	sources combine to produce almost one billion litres of waste-water on an average day. Waste water is also the water used for flushing, bathing, laundry, cleaning dishes, floor drainage etc. It is the water used by factories. Waste water flows into the sewer system and then to a regional waste water treatment plant. It is cleaned and returned to nature.	
c)	Hazards in petrochemical industry ----- In the petrochemical industry (i) fuels like gasoline, diesel fuels, heating oil, kerosene, jet fuel, bunker fuel, oil, liquefied petroleum gas. (ii) Petroleum solvents like benzene, toluene, xylene, hexane and heptane which are used in paint industry (iii) Lubricating oils (iv) Petroleum wax Are the possible hazards in final state and also during being process and refining	1 mark each
d)	C1 hydrocarbon—(i) Methanol (ii)Formaldehyde (iii)Chloromethane (iv)Trichloroethylene C2 hydrocarbon---(i)Ethanol (ii) Ethylene Dichloride (iii) Vinayl Chloride (iv) Ethylene Oxide (v) Styrene	1/2 mark each 1/2 mark for any four

e)	Flowsheet for Vinyl Chloride	4 marks



Q.NO. 6E

Fig. 4.8 : Vinyl chloride via ethylene dichloride pyrolysis