MASTER OF CHEMICAL ENGINEERING EXAMINATION, 2019 (2nd Semester)

PETROLEUM REFINERY ENGINEERING AND PETROCHEMICALS

Time: 3 h | Full Marks 100

Assume any missing data

Terms have usual significance

*Answer any **five** questions*

1. (i) What is the need of Merox sweetening Process? briefly describe fixed bed Merox sweetening Process [process flow diagram not required]. **[5]**

1. (ii) Comment on the properties (RON, CN, pour point, smoke point, viscosity index) of the hydrocarbon molecules (P, iP, N, A) commonly found in petroleum crude. **[5]**

1. (iii) Describe the Acid Gas Sweetening (Girbotol /Amine Treatment) Process using a flow diagram mentioning typical operating conditions of the Absorber and Regenerator units. Comment on the applications of Methyl-di-ethanolamine and Mono/di-ethanolamine as solvents pertaining to feed gas composition. **[10]**

2.(i) Discuss the method of removal of objectionable elements (S, N, O, halides and trace metals) from petrochemical feed stocks by Hydrotreatment mentioning pertinent reactions, catalyst and operating conditions. **[10]**

2. (ii)A naphtha feed stock for a hydrotreater has the following properties:

API gravity=55°

'S' as mercaptans (wt.%)=0.5

'S' as sulfides (wt.%)=0.3

'S' as thiophenes (wt.%)=0.2

'N' as pyrrole (wt.%)= 0.15

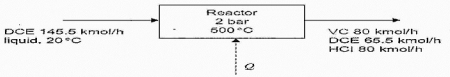
'N' as pyridine (wt.%) =0.10

Compute the H_2 requirement in scft/day for complete removal of 'S' and 'N' from 10000BPD feed. **[10]**

3. (i) In vinyl chloride (VC) manufacture through balanced process, the yield of dichloroethane (DCE) on ethylene is 98% in chlorination; while the yields of DCE are 95 % and 90% on ethylene and HCl respectively in oxyhydrochlorination. In DCE pyrlolysis, the selectivity of DCE to VC is 99% and selectivity to HCl is 99.5%. The conversion of DCE in

pyrolysis reactor is limited to 55%, and the unreacted dichloroethane (DCE) is separated and recycled. Using the yields given, and neglecting any other losses, calculate the flow of ethylene to each reactor and the flow of DCE to the pyrolysis reactor, for a production rate of 12,500 kg/h vinyl chloride (VC). **[12]**

3. (ii) Consider 55% conversion of DCE to vinyl chloride (VC) as shown in the following diagram;



Enumerate the procedure for calculation of 'Q' . Neglect the presence of small quantity of impurities and assume the selectivity for VC to be 100%. **[8]**

4. (i) Define 'Kinetic Severity Function' (KSF) with reference to thermal cracking of naphtha. How is equivalent residence time related to KSF? **[4+2]**

4. (ii) Briefly describe the thermal cracking of naphtha using a simplified process flow diagram mentioning the salient operating conditions. Enumerate the effects of operating parameters on ethylene yield. **[9+5]**

5. (i) Discuss the influence of different operating parameters on each reaction occurring during, catalytic reforming of naphtha. Mentioning the reactions involved, catalyst used, operating condition maintained, discuss catalytic reforming operation using a process flow diagram. **[10]**

5.(ii) Hydrogen is a by-product of catalytic reforming unit of a petroleum refinery, yet it is deliberately added along with the hydrocarbon feed. Why? **[5]**

5. (iii) Calculate the length of time between regeneration of catalyst in a reformer operating at the following conditions:

Liquid hourly space velocity (LHSV) = 3.0 h^{-1}; Feed rate= 5000 BPSD; Feed gravity = 55 °API; Catalyst bulk density = 50 lb/ft^3 ; H_2 to feed ratio = 8000 scft/bbl

Number of reactors =3

Catalyst deactivates after processing 90 bbl of feed per pound of catalyst. If the catalyst bed is 6 ft deep in each reactor, what is the reactor inside diameter? Assume an equal volume of catalyst in each reactor. **[5]**

6.(i) Explain the principle of operation of reactor and regenerator for FCC operation involving gas oil feed stock using proper schematic. **[10]**

6. (ii) The following data (Table 1) have been obtained from the TBP experiment of a crude oil (specific gravity=0.897 at 15.6 °C):

Table 1

TBP range (°C)	C_5 -93	93-175	175-286	286-325	325-365	365-542	>542
Yield(V/V)%	3.00	11.99	30.00	14.00	9.25	26.00	5.14

Draw the TBP assay curve and determine TBP slope and 50% boiling point for the whole crude. Calculate the average boiling point and assess the base of the crude oil.

$$[K = \sqrt[3]{R} \quad /(0.827\rho)]$$

[10]

7.

Consider the conversion of a mixed feed stream of methanol (88 mol%), ethanol (11 mol%), and water (1 mol%) via the following dehydration reactions:

$2CH_3OH \rightarrow (CH_3)_2O + H_2O$ $\quad \Delta H_{reac} = -11{,}770$ kJ/kmol

methanol dimethyl ether (desired product)

$2C_2H_5OH \rightarrow (C_2H_5)_2O + H_2O$ $\quad \Delta H_{reac} = -11{,}670$ kJ/kmol

ethanol diethyl ether (valuable by-product)

$C_2H_5OH \rightarrow C_2H_4 + H_2O$ $\quad \Delta H_{reac} = -1{,}570$ kJ/kmol

ethanol ethylene (less valuable by-product)

The reactions take place in the gas phase, over an alumina catalyst, and are mildly exothermic but do not require additional diluents to control reaction temperature. The stream leaving the reactor (reactor effluent) contains the following components, listed in order of decreasing volatility (increasing boiling point):

1. Ethylene (C_2H_4)
2. Dimethyl Ether (DME)
3. Diethyl Ether (DEE)
4. Methanol (MeOH)
5. Ethanol (EtOH)
6. Water (H_2O)

For this problem, we assume that the mixed alcohol stream is available at a relatively low price from a local source ($0.25/kg). However, pure methanol ($0.22/kg) and/or ethanol ($0.60/kg) streams may be purchased if necessary. The selling price for DME, DEE, and ethylene are $0.95/kg, $1.27/kg, and $0.57/kg, respectively. Preliminary market surveys indicate that we can sell up to 15,000 tonne/y of DEE and up to 10,000 tonne/y of ethylene.

For a proposed process to produce 50,000 tonnes/y of DME, determine the viable process alternatives.

[20]

8. (i) Consider, the following cases and comment on the separation/purification requirements of the feedstock:

(a) Separation of methane from hydrogen in toluene hydrodealkylation process.

(b) Acceptable H_2 levels in CO feeds to phosgene units are less than 1%. Elucidate.

[4+4]

8. (ii) In the production of methanol from synthesis gas route, elucidate the purpose of using "cold (or) hot shot" between staged adiabatic packed beds of catalysts.

[4]

8. (iii) In toluene hydrodealkylation process, diphenyl is also produced as an unwanted product. Briefly justify the recycling option for toluene: (a) Recycle toluene along with diphenyl (b) Separate toluene from diphenyl before recycling. **[4+4]**