

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/Backlog), April-May 2015

B. Tech in Chemical Engineering, Semester VI

Roll No.....

CHE 601: PROCESS DESIGN DECISIONS

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

- Q.1A Objective type multiple choice questions (10 questions @ 1 mark) 10
- i. Level-1 of hierarchy of decisions is:
(a) Input-output structure (b) Recycle structure
(c) Batch or Continuous process (d) Input information of the process
 - ii. If company is making some product suitable for seasonal market, then which type of plant is used:
(a) Batch Plant (b) Continuous Plant (c) both (a) and (b)
 - iii. If x is the per pass conversion of toluene, then toluene leaving the reactor is denoted as:
(a) Toluene Converted = $TOL_{R,in} x$ (b) $TOL_{R,out} = TOL_{R,in} (1 - x)$
(c) $TOL_{R,in} = TOL_{FF} + TOL_{GR} + TOL_{LR}$ (d) $TOL_{FF} = f_{TOL,FF} TOL_{R,out}$
 - iv. Requirement of excess of some reactant is decided in level:
(a) Level -1 (b) Level -2
(c) Level -3 (d) Level -4
 - v. Decision to purify the feed is taken at level:
(a) Level -1 (b) Level -2
(c) Level -3 (d) Level -4
 - vi. For given reaction scheme
$$\left. \begin{array}{l} \text{Acetone} \rightarrow \text{Ketene} + \text{CH}_4 \\ \text{Ketene} \rightarrow \text{CO} + \frac{1}{2} \text{C}_2\text{H}_4 \end{array} \right\} 700^\circ\text{C}, 1 \text{ atm}$$
$$\text{Ketene} + \text{Acetic Acid} \rightarrow \text{Acetic Anhydride} \quad 80^\circ\text{C}, 1 \text{ atm}$$

How many reactors are required
(a) 1 (b) 2 (c) both (a) and (b) are correct
 - vii. Consider a case of HDA process, the toluene fed to the process F_{FT} in terms of selectivity can be represented as
(a) $F_{FT} = \frac{S}{P_B}$ (b) $F_{FT} = \frac{P_B}{S}$ (c) $F_{FT} = \frac{P_B(1-S)}{2S}$ (d) $F_{FT} = \frac{P_B(1-2S)}{S}$
 - viii. Level-5 of hierarchy of decisions is:
(a) Input-output structure (b) Recycle structure
(c) Energy integrated system (d) Structure of separation system



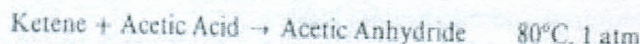
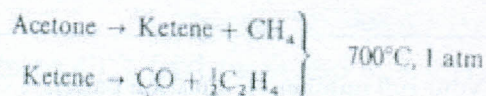


- ix. Define specialty chemical.
- x. What is the benefit of energy integrated process?

Q.2 Short answer type questions (4 questions @ 2.5 marks)

10

- i. Acetic anhydride* can be produced by the reaction system



Assume $\Delta H_{R, \text{acet}} = 34,700 \text{ Btu/mol}$, $\Delta H_{R, \text{ket}} = -27,000 \text{ Btu/mol}$. Neglect the cost of the second reactor. Acetone converted in first reaction is given as 19.06 mol/hr and ketone lost through dissociation in second reaction is given as 2.48 mol/hr. Calculate the reactor heat load.

- ii. Write the formulation of economic potential.
- iii. Name any four vapor recovery system used in industry. How we select the location of vapor recovery system in the process.
- iv. What are the alternative of distillation column in liquid recovery system?

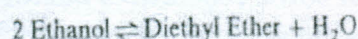
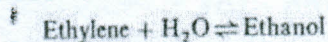
Q.3A What is the hierarchical approach of process design? What are the benefits of using this approach?

05

Q.3B What is the criteria of designing the process in batch or continuous mode?

05

Q.4A The primary reactions are:



The reaction takes place at 560 K and 69 bar. The feed streams are pure water and ethylene stream containing 4% methane as impurity. The desired production rate of the azeotropic product is 783 mol/hr (85.4 mol% EtOH).

(a) Develop recycle flowsheet of the process.

(b) Show that the recycle balance equations of the given case is:

$$F_w = F_{w, R}/X$$

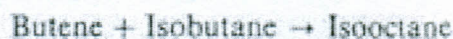
05

Q.4B Write the decisions to be made in detail at level-2 of flowsheet synthesis. Discuss any two in detail.

05

Q.5 A Isooctane (gasoline)[†] can be produced by the reactions

05



The reactions take place in the liquid phase at 45°F and 90 psia; see I

The desired production rate is 918 mol/hr, and the costs are: butene = \$14.56/mol, isobutane = \$18.59/mol, isooctane = \$36.54/mol, and fuel = \$4.00/10⁶ Btu. One feed stream contains 8% C₃, 80% butene, and 12% n-C₄, while the other contains 12% C₃, 73% i-C₄, and 15% n-C₄. Dr

(a) Develop recycle flowsheet at level-3.

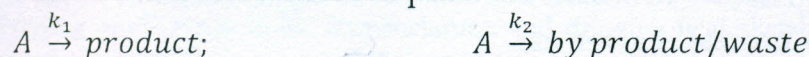
Q.5B What type of input information is required at initial stage of design of a process? Explain any two. 05

Q.6A Discuss in detail the decisions to be made in level 4 of the process. Draw a general structure of the separation system when (i) the reactor effluent is all liquid; (ii) the reactor effluent is two phase system and (3) reactor effluent is all vapor. 05

Q.6B Define selectivity of an HDA Process. 05

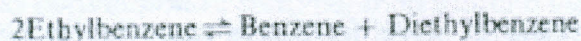
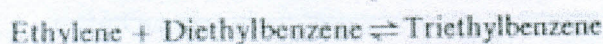
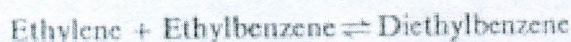
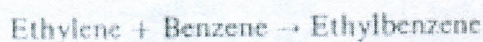
OR

Q.6B Consider two parallel first order isothermal reactions in a batch reactor. Assume that reactant is fed pure. 05

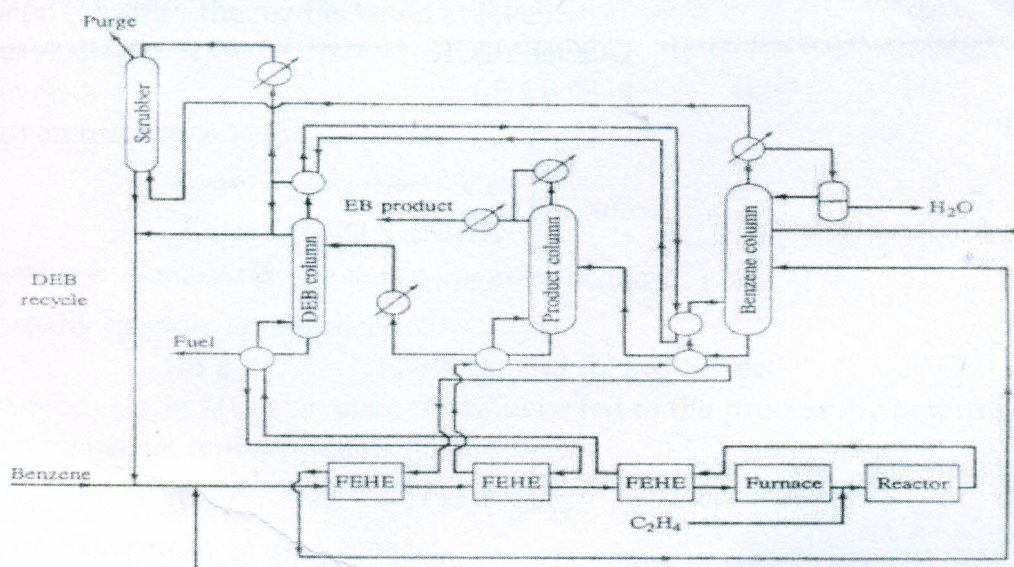


Use kinetic analysis to determine dependency of selectivity on conversion.

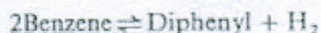
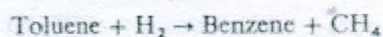
Q.7A An energy-integrated flowsheet for the production of ethylbenzene is given in Fig. The primary reactions are 05



The reaction is run with an excess of benzene and almost complete conversion of the ethylene, to try to minimize the formation of di- and triethylbenzene, and it takes place at 300 psig and 820°F over a catalyst. Two reactors are required (one on stream and the other being regenerated because of coke formation). There is 0.94 % of ethane in the ethylene feed and 0.28 % water in the benzene feed. Develop the hierarchy of flowsheets for this process.



- Q.8A Determine the economic potential of the process of hydrodealkylation of toluene to produce benzene at level-2. Fresh toluene is react with hydrogen stream (contains 95 % hydrogen and 5% methane) to produce benzene. The desired production rate of benzene is 265 mol/hr. 10



Purge stream contains 40 % hydrogen and 60% CH₄. Selectivity of the process is given by $S = 1 - \frac{0.0036}{(1-x)^{1.544}}$. Per pass conversion of toluene could be taken as 0.75. Cost data of HDA process is given as:

Cost data for HDA process

Value of benzene	\$0.85/gal = \$9.04/mol
Value of toluene*	\$0.50/gal = \$6.40/mol
Value of H ₂ feed	\$3.00/1000 ft ³ = \$1.14/mol
Fuel = \$4.0/10 ⁶ Btu	
Fuel value: H ₂	0.123×10^6 Btu/mol
CH ₄	0.383×10^6 Btu/mol
Benzene	1.41×10^6 Btu/mol
Toluene	1.68×10^6 Btu/mol
Diphenyl†	2.688×10^6 Btu/mol



- Q.9A Suppose you are working in some fertilizers manufacturing company. Your company want to start one more manufacturing plant. How you check the feasibility of your company plan? 10
- Q.9B Write material balance equations of HDA process in level - 2. 15
- OR
- Q.9B Write material balance equations of HDA process in level - 4. 15

***** GOOD LUCK *****