BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI I CAMPUS
II Semester 2016-2017
CHE F 419: Chemical Process Technology
Mid semester test: 11/03/2017
PART-B: Open Book

Time: 30 minutes **Max. Marks: 25**

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1. **2.7 billion lb/stream day of ethylene is produced using commercial grade ethane as feedstock using steam reformer. Ethane arrives in liquid state at 700 psig and 80° F: Reactants & Product specs.**
   a. **Show what all steps would be needed to complete the design of steam cracker.**
   b. **Carry out the complete material balance for the given process..**
   c. **Draw the schematic of steam cracker showing all the inputs & outputs from the cracker.**

SNO	Component	Mole %
1.	CH_4	3
2.	C_2H_6	94
3.	C_3H_8	3
4.	CO_2	800 ppm
5.	S	Very less in ppm

SNo	Component	Mole %
1.	CH_4	0.6
2.	C_2H_6	0.4
3.	C_2H_4	99
4.	C_2H_2	<10 ppm
5.	H_2S	<5 ppm
6.	CO_2	<100 ppm

			A	E, kcal/g mole
Initiation	$C_2H_6 \rightarrow 2CH_3\cdot$	(1)	1.0×10^{16}	86
Propagation	$CH_3 + C_2H_6 \rightarrow CH_4 + C_2H_5\cdot$	(2)	3.16×10^{8}	10.8
	$C_2H_5\cdot \rightarrow C_2H_4 + H$	(3)	3.98×10^{13}	38
	$H\cdot + C_2H_6 \rightarrow H_2 + C_2H_5\cdot$	(4)	1.25×10^{11}	9.7
Termination	$C_2H_5\cdot + C_2H_5\cdot \rightarrow n\text{-}C_4H_{10}$	(5a)	2.511×10^{10}	0
	$C_2H_5\cdot + C_2H_5\cdot \rightarrow C_2H_6 + C_2H_4$	(5b)		
Propylene formation	$C_2H_5\cdot + C_2H_4 \rightarrow C_3H_6 + CH_3\cdot$	(6)	3.16×10^{9}	19
	$C_2H_5\cdot + C_2H_4 \rightleftarrows 1\text{-}C_4H_9\cdot$			
	$1\text{-}C_4H_9\cdot \rightarrow 2\text{-}C_4H_9\cdot$			
	$2\text{-}C_4H_9\cdot \rightarrow C_3H_6 + CH_3\cdot$			
Inhibition	$H\cdot + C_2H_4 \rightarrow C_2H_5\cdot$	(7)	5.0118×10^{10}	−0.8

Units for $\mathbf{A} = \text{sec}^{-1}$ for Reactions 1 and 3, and 1.(g mole)$^{-1}$sec^{-1} for others.

Fig. CS-2.1 Free-radical mechanism for ethane cracking. [Reaction 5*a* can be neglected in terms of product produced and a combined rate constant used, $k_5 = 1.15k_{5a}(1)$. Rate equations in terms of partial pressures may be written using $R'T$ corrections.]

The first-order rate constant for ethane is obtained from Table 10.4, p. 446[1].

$$k_c = 4.717 \times 10^{14}\, e^{-72{,}240/R'T},\ \text{sec}^{-1} \qquad \text{(CS-2.1)}$$

where $T = °\text{K}$ or

$$k_p = \frac{k_c}{RT} = \frac{4.717 \times 10^{14}}{RT}\, e^{-130{,}032/R'T},\ \frac{\text{lb mole}}{(\text{atm})(\text{ft}^3)(\text{sec})} \qquad \text{(CS-2.2)}$$

where $T = °\text{R}$ and $R = 0.73$.