## **V SEMESTER B.TECH. END SEMESTER EXAMINATIONS JAN-FEB 2021**

## SUBJECT: CHEMICAL REACTION ENGINEERING [CHE 3151]

## **REVISED CREDIT SYSTEM**

Time: 3 Hours

MAX. MARKS: 50

## Instructions to Candidates:

- ✤ Answer ALL the questions.
- ✤ Missing data may be suitable assumed.
- ✤ Use graphs wherever relevant.

IA.A rocket engine burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid oxygen). The combustion chamber is a cylinder of length 0.75 m and diameter 0.60 m. The combustion reaction $H_2 + \frac{1}{2} \ O_2 \rightarrow H_2 O$ produces 108 kg/s of exhaust gases. If the combustion is complete, find the rate of reaction of i) hydrogen and ii) oxygen in mol/m <sup>3</sup> . s <b>1B.</b> The maximum allowable temperature for a reactor is 800 K. At present our operating set point is 780 K. Now, with a more sophisticated control system we would be able to raise our set point to 792 K. By how much can the reaction rate be raised by this change if the reaction has an activation energy of 175 KJ/mol?O <b>1C.</b> Deduce a mechanism that is consistent with the experimentally found rate equation for the following reaction $2A + B \rightarrow A_2B$ $+r_{A_2B} = k[A][B]$ O <b>2A.</b> Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change.O	A rocket engine burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid oxygen). The combustion chamber is a cylinder of length 0.75 m and diameter 0.60 m. The combustion reaction041A. $H_2 + \frac{1}{2} O_2 \rightarrow H_2 O$ produces 108 kg/s of exhaust gases. If the combustion is complete, find the rate of reaction of i) hydrogen and ii) oxygen in mol/m <sup>3</sup> . s041B.The maximum allowable temperature for a reactor is 800 K. At present our operating set point is 780 K. Now, with a more sophisticated control system we would be able to raise our set point to 792 K. By how much can the reaction rate be raised by this change if the reaction has an activation energy of 175 KJ/mol?031C.Deduce a mechanism that is consistent with the experimentally found rate equation for the following reaction $2A + B \rightarrow A_2B$ $+r_{A_2B} = k[A][B]$ 032A.Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change.05	A rocket engine burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid oxygen). The combustion chamber is a cylinder of length 0.75 m and diameter 0.60 m. The combustion reaction04 <b>1A.</b> $H_2 + \frac{1}{2} O_2 \rightarrow H_2 O$ produces 108 kg/s of exhaust gases. If the combustion is complete, find the rate of reaction of i) hydrogen and ii) oxygen in mol/m <sup>3</sup> . s04 <b>1B.</b> The maximum allowable temperature for a reactor is 800 K. At present our operating set point is 780 K. Now, with a more sophisticated control system we would be able to raise our set point to 792 K. By how much can the reaction rate be raised by this change if the reaction has an activation energy of 175 KJ/mol?03 <b>1C.</b> Deduce a mechanism that is consistent with the experimentally found rate equation for the following reaction $2A + B \rightarrow A_2B$ $+r_{A_2B} = k[A][B]$ 03 <b>2A.</b> Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change.05 <b>2B.</b> () Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at $2410^{\circ} R = 5 \text{ thm} (C_{\circ} = 0.00 \text{ CP mol}/h)$ 2+3	A ro oxyg com 1A. H <sub>2</sub> - proc of i) The	bocket engine burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid gen). The combustion chamber is a cylinder of length 0.75 m and diameter 0.60 m. The abustion reaction $+\frac{1}{2} O_2 \rightarrow H_2 O$ duces 108 kg/s of exhaust gases. If the combustion is complete, find the rate of reaction hydrogen and ii) oxygen in mol/m <sup>3</sup> . s	04								
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$+r_{A_2B} = k[A][B]$ 2A. Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change. 09	$+r_{A_2B} = k[A][B]$ 2A. Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change. A homogeneous gas phase reaction $A > 3B$ has a rate, $r_1 = 0.01 \text{ C} \frac{1/2}{2}$ mol/l set at 315 %	$+r_{A_2B} = k[A][B]$ Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change.052A.A homogenous gas phase reaction A-> 3R has a rate $-r_A = 0.01 C_A^{1/2}$ mol/l sec at 215 °C.052B.i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at $245\% C_B C_B$ struct $C_B = 0.0225$ mol/l2+3	2 <i>A</i> ·	$+ B \rightarrow A_2 B$	03								
<b>2A.</b> Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change. <b>0</b>	<b>2A.</b> Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change. <b>05A</b> homogeneous gas phase reaction $A > 3P$ has a rate, $r_1 = 0.01 \text{ GeV}^2$ mol/l set at 315 $^{9}$ C	2A.       Deduce the performance equation from basic principles for an ideal batch reactor for a gas phase reaction with significant density change.       05         A homogenous gas phase reaction A-> 3R has a rate $-r_A = 0.01 C_A^{1/2}$ mol/l sec at 215 °C.       05         2B.       1) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at 2+3       2+3	$+r_A$	$k_{2B} = k[A][B]$									
gas phase reaction with significant density change.	gas phase reaction with significant density change. A homogeneous gas phase reaction $A > 3P$ has a rate, $r_1 = 0.01 \text{ C} \frac{1/2}{2} \text{ mol}/1 \text{ set at } 315 ^{9}\text{C}$	2A.gas phase reaction with significant density change.05A homogenous gas phase reaction A-> 3R has a rate $-r_A = 0.01 C_A^{1/2}$ mol/l sec at 215 °C.05i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at2+3	Ded	luce the performance equation from basic principles for an ideal batch reactor for a	05								
	A homogeneous gas phase reaction $A > 3P$ has a rate, $r_{\rm c} = 0.01 \text{ G} \frac{1/2}{2} \text{ mol}/1 \text{ sec at } 315 ^9\text{C}$	<b>2B.</b> A homogenous gas phase reaction A-> 3R has a rate $-r_A = 0.01 C_A^{1/2}$ mol/l sec at 215 °C. i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at 2+3	gas	phase reaction with significant density change.	05								
A homogenous gas phase reaction A-> 3R has a rate $-r_A = 0.01 C_A^{1/2}$ mol/l sec at 215 °C.	A nonogenous gas phase reaction A-> SK has a rate -r <sub>A</sub> - 0.01 C <sub>A</sub> / mol/1 set at 215 °C.	<b>2B.</b> i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at <b>2+3</b>	A ho	omogenous gas phase reaction A-> 3R has a rate $-r_A = 0.01 C_A^{1/2}$ mol/l sec at 215 °C.									
i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at	i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at	<b>2D.</b> $215^{0}$	i) Ch	i) Choose the best flow reactor to achieve 80% conversion of a 50% A-50% inert feed at									
215°C & 5 atm; $C_{A0}$ = 0.0625 mol/l.	2B / 2+2	$215^{\circ}$ C & 5 atm; CA0= 0.0625 m01/1.	20.	215 <sup>o</sup> C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l.									
ii) Find the space time peeded	<b>2B.</b> $215^{\circ}$ C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l. <b>2+3</b>		ii) F										
ii) Find the space time needed.	<b>2B.</b> 215°C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l. <b>2+3</b> ii) Find the space time needed. <b>2</b>	II) Find the space time needed.	i) V	What is the purpose of using recycle stream in a PFR?									
i) What is the purpose of using recycle stream in a PFR?	2B.       215°C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l.       2+3         ii) Find the space time needed.       i) What is the purpose of using recycle stream in a PFR?	i) Find the space time needed.         i) What is the purpose of using recycle stream in a PFR?	ii) C	Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction.	2.2.2								
<ul> <li>i) What is the purpose of using recycle stream in a PFR?</li> <li>ii) Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction.</li> </ul>	<ul> <li>2B. 215°C &amp; 5 atm; C<sub>A0</sub>= 0.0625 mol/l.</li> <li>ii) Find the space time needed.</li> <li>i) What is the purpose of using recycle stream in a PFR?</li> <li>ii) Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction.</li> </ul>	<ul> <li>i) Find the space time needed.</li> <li>i) What is the purpose of using recycle stream in a PFR?</li> <li>ii) Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction.</li> </ul>	20	Justify your choice.									
<ul> <li>ii) What is the purpose of using recycle stream in a PFR?</li> <li>ii) Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction. Justify your choice.</li> </ul>	2B.       215°C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l.       2+3         ii) Find the space time needed.       ii) What is the purpose of using recycle stream in a PFR?         ii) Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction.       2+3+4         Justify your choice.       2+3	ii) Find the space time needed.         i) What is the purpose of using recycle stream in a PFR?         ii) Choose among PFR, CSTR and PFR with recycle to perform an autocatalytic reaction.         Justify your choice.	<b>ЗА.</b> Ј	ustify your choice.									
<b>2B.</b> $215^{\circ}$ C & 5 atm: C <sub>40</sub> = 0.0625 mol/l.		$215^{\circ}$ U & 5 atm: $140$ = $1.00$ / $1.00$	<b>2B.</b> 21	215°C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l.									
ii) Find the space time needed	<b>2B.</b> $215^{\circ}$ C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l. <b>2+3</b>		ii) F										
ii) Find the space time needed.	2B.       215°C & 5 atm; C <sub>A0</sub> = 0.0625 mol/l.       2+3         ii) Find the space time needed.       2+3	II) Find the space time needed.	i) V	What is the purpose of using recycle stream in a PFR?									

3B.	Define D	amköh	ler nu	mber.	Explai	n its re	levance	e to rea	actors i	n series.				03
	Substand	ce A in a	a liqui	d phas	e reac	tion pr	oduces	R and	S as fo	llows:				
4A.	Both are	first or	der re	eaction	s with	rate co	onstant	s k₁ an	d k2. A	feed (Ca	<sub>0</sub> = 1, C <sub>1</sub>	$R_0 = 0, C_s$	<sub>0</sub> = 0)	4+3
	enters two mixed flow reactors in series, ( $\tau_1$ = 2.5 min, $\tau_2$ = 5 min). Knowing composition in the first reactor ( $C_{A1}$ = 0.4, $C_{R1}$ = 0.4, $C_{S1}$ = 0.2)											g the		
	i) Find t	ne rate	const	ants.	-									
	ii) Find t	he com	positi	ion (C <sub>A2</sub>	2, C <sub>R2</sub> ,	C <sub>s2</sub> ) lea	aving th	ie seco	nd read	ctor.				
4B.	Starting competi A + B - R + B - sketch th	with stive-conductive $R_{desi}$ $R_{desi}$ $R_{unw}$ $R_{unw}$ $R_{unw}$	separa nsecu <sup>.</sup> red ; 1 anted ; conta	tive reactive reactive $r_{1=} k_1 $ $r_2 = k_1$	eds of action $C_A C_B$ $k_2 C_R$ attern	react s with s $C_B^2$ ns for b	ant A stoichic	and B ometry ntinuou	and rat	ven con te as shc batch op	centration	tion, for	the	03
5A.	Discuss t	he vari	ous n	on idea	l flow	patter	ns whi	ch exist	t in pro	cess equ	ipment	t.		3
5B.	Derive a bypass a	n expre nd dea	ession d spac	for con ce. (Eva	versio Iluatio	on for a on of m	first or odel pa	rder rea aramet	action, ers <b>not</b>	in a real require	CSTR m d).	nodeled	using	4
5C.	A sampl concentr calculate t(min) C(t) g/m <sup>3</sup>	e of a ration y ed. 1	trace was n 2 5	r at 32 neasure 3 8	0 K v ed as 4 10	vas inje a func 5 8	ected a ction o 6 6	as a pu f time 7 4	llse to given 8 3	a reacto in the t 9 2.2	or, and able. A 10 1.5	the eff lso, E(t) 12 0.6	luent was	3
	E(t) min <sup>-1</sup> Find the	0.02 mean i	0.1 reside	0.16 nce tim	0.2 ne?	0.16	0.12	0.08	0.06	0.044	0.03	0.012	0	