INSTRUCTIONS

1. **This question paper consists of two parts. Part A is close book and Part B is open (only text) book.**
2. **Part-B answer book will be supplied after you return Part-A answer book.**
3. **Make and state suitable, logical and justifiable assumptions if necessary.**
4. **Give just 2 iterations for iterative procedure(s).**
   Be to the point. Do not be descriptive. Use as less words as possible.

PART A (CLOSE BOOK)

Q1 [Marks 25] (a) Give the CRE algorithm **[1]; (b)** List 5 criteria used to evaluate laboratory rectors **[5]; (c)** We can use membrane reactors to increase the selectivity in multiple reactions (*True or False*) **[1]; (d)** Justify: "*in no other type of reaction is exactness in the calculation of the time needed to carry out the reaction more important than in series reactions"* **[3]; (e)** Define turnover frequency and dispersion in the context of catalysis **[2]; (f)** Use well-labelled schematics to describe 3 surface reaction models **[5]; (g)** What do 3 main moments of RTD signify? **[3]; (h)** Which 5 models help us to predict the conversion (in non-ideal reactors) from RTD data? Categorize them in 3 groups **[5].**

PART B (ONLY OPEN TEXT BOOK)

Q2 [Marks 20] Compound A undergoes a reversible isomerization reaction, $A \rightleftharpoons B$, over a supported metal catalyst. Under pertinent conditions, A and B are liquid, miscible, and of nearly identical density; the equilibrium constant for the reaction (in concentration units) is 5.8. In a fixed-bed isothermal flow reactor in which back mixing is negligible, a feed of pure A undergoes a net conversion to B of 55%. The reaction is elementary. If a second, identical flow reactor at the same temperature is placed downstream from the first, what overall conversion of A would you expect if the reactors are directly connected in series?

Q3 [Marks 20] For the given (to your RHS) set of reactions, describe 3 reactor systems and conditions to maximize the selectivity to the desired product D. Make sketches (schematics) to support your choices. The rates are in (mol/dm^3.s), and concentrations are in (mol/dm^3). Say: T_1 and T_2 = 300 and 1000 K.

(1) $A + B \rightarrow D$ $\quad -r_{1A} = 10\exp(-8{,}000\ \text{K}/T)C_A C_B$

(2) $A + B \rightarrow U$ $\quad -r_{2A} = 100\exp(-1{,}000\ \text{K}/T)C_A^{1/2} C_B^{3/2}$

PTO

Q4 [Marks 15] The endothermic liquid-phase elementary reaction $A + B \rightarrow 2C$ proceeds, substantially, to completion in a single steam-jacketed, continuous-stirred reactor. From the following data, calculate the steady-state reactor temperature: Reactor volume: 125 gal; Steam jacket area: 10 ft^2; Jacket steam: 150 psig (365.9^{0}F saturation temperature); Overall heat-transfer coefficient of jacket, *U*: 150 Btu/h.ft^2.^{0}F; Agitator shaft horsepower: 25 hp; Heat of reaction, ΔH^0_{Rx}= +20,000 Btu/lb mol of A (independent of temperature).

	Component		
	A	*B*	*C*
Feed (lbmol/hr)	10.0	10.0	0
Feed temperature (°F)	80	80	—
Specific heat (Btu/lb mol·°F)*	51.0	44.0	47.5
Molecular weight	128	94	222
Density (lb/ft³)	63.0	67.2	65.0

*Independent of temperature.

Q5 [Marks 20] The following reactions take place on a nickel catalyst (spherical particles):

Overall reaction : $A + B \rightarrow C$

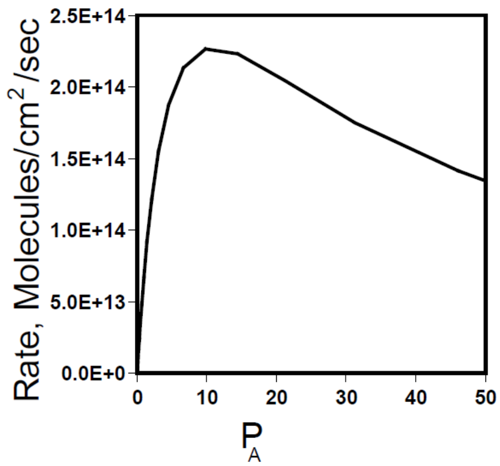
Adsorption : $A + Ni \leftrightarrow A.Ni$

$B + Ni \leftrightarrow B.Ni$

Reaction : $A.Ni + B.Ni \rightarrow C + 2\,Ni$

Determine the rate determining step (RDS) and rate of formation of C (r_C) in consistent with the experimental data. (1 mole = 6.023 x 10^{23} molecules).

Figure (RHS): A plot of the experimental (formation) rate of *C* (r_C) with $K_B P_B$ = 10. (K_B = Adsorption constant of B, P_B= partial pressure of *B*, P_A = partial pressure of A)



Q6 [Marks 20] The flow through a reactor is 10 dm^3/min. A pulse test gave the concentration measurements at the outlet as given in the table to your right:

(a) Plot the external age distribution *E(t)* as a function of time.

(b) What are the mean residence time t_m , and the variance, σ^2?

t (min)	$c \times 10^5$	*t* (min)	$c \times 10^5$
0	0	15	238
0.4	329	20	136
1.0	622	25	77
2	812	30	44
3	831	35	25
4	785	40	14
5	720	45	8
6	650	50	5
8	523	60	1
10	418		

END