Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course: Chemical Reaction Engineering II — **Semester: VI**
Program: B.Tech. CERP — **Time 03 hrs.**
Course Code: CHEG334 — **Max. Marks: 100**

Instructions: (i) This question paper has three sections- A, B and C. All questions of each section are compulsory Question No. 10 has internal choice.
(iii) Attempt all the sub-parts of a question together.

SECTION A (20 Marks)

S. No.		Marks	CO
Q 1	Explain the meaning of complete micro-mixing and complete segregation. Give an example from real life (not from reaction engineering) to illustrate and explain in the meaning.	**05**	**CO1**
Q 2	Write in brief about the various methods for preparation of catalysts.	**05**	**CO3**
Q 3	Does a catalyst alter equilibrium conversion of a chemical reaction? Explain.	**05**	**CO2**
Q 4	What is the importance of pores in a catalyst particle? Differentiate micro and macro pore.	**05**	**CO4**

SECTION B (60 Marks)

S. No.		Marks	CO
Q 5	Discuss in detail about different types of adsorption and derive the Langmuir adsorption isotherm expression for molecular adsorption with suitable assumptions.	**12**	**CO3**
Q6	Gaseous feed with A and B (v_o = 10 m^3/hr) pass through as experimental reactor packed with the catalyst (W= 4 kg). Reaction occurs as follows: $A + B \longrightarrow R + S$, $-r_A = 0.6\ C_A C_B$ mol/ kg. hr. Find the conversion of reactants if the feed contains C_{Ao} = 0.1 mol/m^3 and C_{Bo} = 10 mol/m^3.	**12**	**CO4**
Q 7	From a pulse input into a vessel we obtain the following output signal and represented by tank-in-series model. Determine the number of tank to use. Time, min: 1, 3, 5, 7, 9, 11, 13, 15 Concentration(arb): 0, 0, 10, 10, 10, 10, 0, 0	**12**	**CO2**
Q 8	Give significance of Effectiveness factor for solid catalyzed reaction. Derive a relationship between effectiveness factor and Thiele Modulus for first order kinetics.	**12**	**CO4**
Q 9	The following data on an irreversible reaction are obtained with decaying catalyst in a batch reactor (batch-solids, batch-fluid) what can you say about kinetics: C_A: 1.000, 0.802, 0.675, 0.532, 0.422, 0.363	**12**	**CO5**

Q 7 data:

Time, min	1	3	5	7	9	11	13	15
Concentration(arb)	0	0	10	10	10	10	0	0

Q 9 data:

C_A	1.000	0.802	0.675	0.532	0.422	0.363

	T, hr | 0 | 0.25 | 0.5 | 1 | 2 | (∞)		
SECTION-C (20 marks)			
Q 10	Develop the overall rate equation for the gas-phase heterogeneous reaction; The effect of diffusive mass transfer may be neglected. $A \longrightarrow M + N$, considering the following steps: i. adsorption of A, ii. surface reaction between the adsorbed A and adjacent site to produce adsorbed M and adsorbed N, and iii. desorption of M and N Assume step (ii) is controlling. **(OR)** **(a).** Explain the steps involved in heterogeneous catalytic reaction with any example. **(b).** The oxidation of methanol to formaldehyde in presence of solid oxide catalyst was studied with a recycle. The rate of circulation of the mixture (with a pump) was much higher than feeding rate and removal of product. The following reaction takes place: $CH_3OH + 0.5\, O_2 \longrightarrow CH_2O + H_2O$ $CH_2O + 0.5O_2 \longrightarrow CO + H_2O$ ――――――――――――――― $CH_2O + 0.5O_2 \longrightarrow CO + 2H_2O$ The gas flow rate was 10 liters/hr, catalyst volume = 5 cm^3, C_{Ao} = 6.5 by volume, overall conservation 98% and yield of formaldehyde as 0.9%. Calculate the rate constants for both the reactions in presence of catalyst.	**20**	**CO5**

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SECTION A (20 Marks)

S. No.		**Marks**	**CO**
Q 1	Describe pulse input experiment for RTD measurement.	**05**	**CO1**
Q 2	Explain the nature of catalytic surface with suitable examples.	**05**	**CO3**
Q 3	Brief the Langmuir Hinshelwood mechanism.	**05**	**CO2**
Q 4	What do you mean by rate controlling step in heterogeneous reactions?	**05**	**CO4**

SECTION B (60 Marks)

Q 5	Derive an expression for first order solid catalyzed reaction considering pore diffusion.	**12**	**CO3**
Q6	(a)For a catalytic reaction of type A + B ↔ P what is possible driving force if: (i) Adsorption of A controls the rate. (ii) Surface reaction controls rate. (b) Give reasons for catalyst deactivation.	**12**	**CO4**
Q 7	The concentration reading in given table represents a continuous response to a pulse input in a closed vessel and is well represented by the dispersion model. Calculate the vessel dispersion number D/uL. The C versus t tracer response of this vessel is:	**12**	**CO2**

t, min	0	5	10	15	20	25	30	35
C_{pulse}, gm/lit	0	3	5	5	4	2	1	0

Q 8	The rate law of hydrogenation (H) of ethylene (E) to form ethane (A) over a cobalt-molybdenum catalyst is: $$-r_R=\frac{k P_E P_H}{1+K_E P_E}$$ Suggest a mechanism & rate limiting step consistent with the rate law given.	**12**	**CO4**
Q 9	The following kinetic data on the reaction A → R are obtained in an experimental packed bed reactor using various amounts of catalysts and a fixed feed rate F_{A0}= 10 kmol/hr. (a) Find the reaction rate at 40% conversion	**12**	**CO5**

	(b) In designing a large packed bed reactor with feed rate F_{Ao} = 400 kmol/hr how much catalyst would be needed for 40% Conversion.		

W, K_f cat	1	2	3	4	5	6	7
X_A	0.12	0.20	0.27	0.33	0.37	0.41	0.44

SECTION-C (20 marks)

Q 10	**(a).** For catalytic kinetics discuss differential & integral reactors. **(b).** In the case of catalyst decaying, it is practiced to feed with the new catalyst to keep the level of activity constant. The relation between conversion, activity of catalyst and catalyst weight is given by $$W = \frac{F_{Ao} X_A}{-r_A} = \frac{F_{Ao} X_A}{\acute{a} k_o A^n C}$$ Where, $\acute{a}$, represents mean activity in the reactor. Determine the mean activity for first order decay in C.S. T. R.	**20**	**CO5**