CHEMICAL REACTION ENGINEERING II
(CHEN 3111)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) In homogeneous catalyzed system, the observed rate is the
(a) rate due to catalyzed reaction only
(b) rate due to uncatalyzed reaction only
(c) rate due to both uncatalyzed and catalyzed reactions
(d) none of the above

(ii) In an autocatalytic reaction A + R = R + R, the rate follows
(a) a parabola with a maximum where concentration of A and R are equal
(b) a parabola with a maximum where concentration of A is greater than R
(c) a parabola with a maximum where concentration of R is greater than A
(d) none of the above

(iii) Nitrogen Desorption Method is used to measure
(a) Surface area of catalyst
(b) Surface area and pore volume distribution of catalyst
(c) Pore volume distribution of porous catalyst
(d) All of the above

(iv) Precipitation method is a method of obtaining the solid catalyst
(a) in a porous form (b) in a nonporous form
(c) in an amorphous form (d) none of the above

(v) For a first order chemical reaction in a porous catalyst, the Thiele modulus is 10. The effectiveness factor is approximately equal to
(a) 1 (b) 0.5 (c) 0.1 (d) 0

(vi) Choose the correct statement
(a) In burning of coal, progressive conversion model is closely followed.
(b) In burning of coal, unreacted-core model is closely followed.

(c) In burning of coal, both progressive conversion model and unreacted-core model model are followed.
(d) In burning of coal, none of progressive conversion or unreacted-core model is followed.

(vii) In cement-kilns, fluid-solid contacting pattern is
(a) cross current (b) co-current
(c) counter current (d) none of these

(viii) In G/L reactions for gases of high solubility, _____ is to be avoided
(a) agitated tank (b) bubble contactor
(c) plate column (d) spray contactor

(ix) Tank-in-series model belongs to
(a) zero adjustable parameter model (b) one adjustable parameter model
(c) two adjustable parameter model (d) none of the above

(x) In slurry reactor, if catalyst particle size is increased
(a) resistance to gas absorption increases
(b) resistance to gas absorption decreases
(c) resistance to gas absorption remains unaffected
(d) resistance to transport to catalyst surface decreases.

Group- B

2. (a) What do you understand by catalyst deactivation? Discuss in details different reasons for catalyst deactivation. [(CO1) (Understand/LOCQ)]

(b) Discuss in details how the surface area of catalyst is estimated by BET method. [(CO2)(Analyze/IOCQ)]

6 + 6 = 12

3. (a) Define:
(i) Catalyst
(ii) Promoter
(iii) Inhibitor. [(CO1) (Remember/LOCQ)]

(b) Discuss in details the general methods of catalyst preparation. [(CO1) (Analyze/IOCQ)]

(c) Discuss in details how the surface area of catalyst is estimated by BET method. [(CO2)(Analyze/IOCQ)]

3 + 5 + 4 =12

Group – C

4. (a) Discuss in details various factors affecting the rate of a gas phase reaction catalysed by a solid porous catalyst. [(CO3) (Analyze/IOCQ)]

(b) The following kinetic data on the reaction A → R are obtained in an experimental packed bed reactor using various amounts of catalyst and a fixed feed rate *FA,* = 10 kmol/hr.

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

(i) Find the reaction rate at 40% conversion.
(ii) In designing a large packed bed reactor with feed rate F_{A0} = 400 kmol/hr how much catalyst would be needed for 40% conversion.
(iii) How much catalyst would be needed in part (ii) if the reactor employed a very large recycle of product stream. [(CO3) (Evaluate/HOCQ)]

6 + 6 = 12

5. At 700^0C the rate of decomposition A → 3R, on a specific catalyst of given size is found to be

$$-r_A' = -\frac{1}{w}\frac{dN}{dt} = 10\ \frac{liter}{gmcat.hr}\ C_A$$

A pilot plant is to be built. This is to be a tubular packed bed 2 cm ID using 25% of these active catalyst pellets evenly mixed with 75% inert pellets to insure isothermal operations. For 400 mol / hr feed consisting of 50% A – 50% inert gas at 8 atm and 700^0C what must be the length of reactor so that p_{Aout}/p_{Ain} = 0.111.
Data: catalyst and inert pellets are porous, of diameter d_p = 3 mm, particle density = 2 gm/cm^3. Bulk voidage of packed bed = 50%. [(CO3) (Evaluate/HOCQ)]

12

Group - D

6. (a) Mention the difference between SCM model and PCM model in case of fluid-particle reactions. [(CO4) (Remember/LOCQ)]

(b) Give one example for each of fluid-particle reaction (following SCM model) of changing size and unchanging size. [(CO2) (Remember/LOCQ)]

(c) A solid feed consisting of the following sized particles: 25 wt% of 1 mm particles and smaller, 35 wt% of 2 mm particles and smaller, Rest 3 mm particles and smaller. The feed passes through a rotating tubular reactor somewhat like a cement kiln where it reacts with a gas to give a hard non-friable solid product (SCM/reaction control, $\tau = 3h$ for 3mm particles). Find the mean conversion of the solids for a residence time of 45 minutes. [(CO4)(Evaluate/HOCQ)]

2 + 2 + 8 = 12

7. (a) Derive the equation relating time versus conversion in case of non-catalytic gas-solid reaction (following shrinking-core model) for spherical particle where diffusion gas-film controls. [(CO4) (Analyze/IOCQ)]

(b) A batch of solids of uniform size is treated by gas in a uniform environment. Solid is converted to give a non-flaking product according to the shrinking-core model. Conversion is about $\frac{7}{8}$ for a reaction time of 1 hr., conversion is complete in 2 hrs. Which mechanism is rate controlling? Justify. [(CO4) (Evaluate/HOCQ)]

6 + 6 = 12

Group - E

8. (a) Mention the reaction steps in a slurry reactor. [(CO5) (Remember/LOCQ)]

   (b) Obtain generalized rate equation for reaction taking place in a slurry reactor. [(CO5) (Analyze/IOCQ)]

   (c) Discuss the effect of catalyst particle size on the reaction rate in a slurry reactor. [(CO5)(Analyse/IOCQ)]

2 + 8 + 2 = 12

9. (a) A 2nd order reaction (A→R) is being carried out in a real reactor. The real reactor may be modelled as a combination of an ideal CSTR followed by a PFR. Obtain the conversion of A.

   (b) Will the conversion be different if the real reactor would have been modelled as an ideal PFR followed by CSTR –Justify.
   Given : Residence time in CSTR & PFR = 1 min. Initial concentration of A = 2 Kmol/m^3, reaction rate constant = 1.0 m^3/kmol.min. [(CO5) (Evaluate/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	15.6	38.6	45.8

Course Outcome (CO):

After the completion of the course students will be able to

1. to participate in catalyst development programme.
2. to characterize newly developed catalyst.
3. to design catalytic reactors.
4. to design non catalytic reactors involving solid fluid reaction.
5. to design reactors involving mass transfer with chemical reactions.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.

Department & Section	Submission Link
CHE	https://classroom.google.com/c/MTI2NTM5MTg1NjE3/a/NDYzOTE1NDk0NjQ1/details