Register Number: ……..

B.TECH DEGREE EXAMINATIONS: MAY/JUNE 2013

Sixth Semester

BIOTECHNOLOGY

BTY120**:** Chemical Reaction Engineering

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. _____ explains the mechanism of catalysis

   a) Activated complex theory b) Collision theory

   c) Kinetic theory d) Thermodynamics

2. From collision theory, the reaction rate constant is proportional to

   a) $\exp\left(-\frac{E}{RT}\right)$ b) $T^m \cdot \exp\left(-\frac{E}{RT}\right)$

   c) T d) $T^{0.5}$

3. The fractional volume change of the system for the isothermal gas phase reaction, A →3B, between no conversion and complete conversion is

   a) 1 b) 2

   c) 3 d) 4

4. The conversion for a first order liquid phase reaction, A →B in a CSTR is 50%. If another CSTR of the same volume is connected in series, then the % conversion at the exit of the second reactor will be

   a) 60 b) 75

   c) 90 d) 100

5. The exit age distribution curve E(t) for an ideal CSTR with the average residence time, τ, is given by

   a) $e^{-t/\tau}$ b) $1 - e^{-t/\tau}$

   c) $1 - \left(\frac{e^{-t/\tau}}{\tau}\right)$ d) $\frac{e^{-t/\tau}}{\tau}$

6. What is the dispersion number for a CSTR?

   a) 0 b) 1

   c) <1 d) ∞

7. Design of heterogeneous catalytic reactor involves consideration of _____ steps
   a) Only chemical
   b) Only physical
   c) Both (a) and (b)
   d) Neither (a) nor (b)
8. Which of the following resistances is not involved in a gas phase catalytic (gas-solid) reaction?
   a) Ash resistance
   b) Surface phenomenon resistance
   c) Gas film and pore surface diffusion resistances for reactants
   d) Gas film and pore surface diffusion resistances for products
9. A catalyst
   a) initiates a reaction
   b) is capable of reacting with the reactants
   c) lowers the activation energy of reacting molecules
   d) cannot be recovered chemically unchanged at the end of a chemical reaction
10. From among the following, choose one which is not an exothermic process
   a) Methanol synthesis
   b) Catalytic cracking
   c) Ammonia synthesis
   d) Oxidation of sulphur

PART B (10 x 2 = 20 Marks)

11. Differentiate series and parallel reactions.
12. A reaction has the stoichiometric equation, $A + B \leftrightarrow 2R$, $-r_A = kC_AC_B$, what is the order of reaction?
13. Write short notes on batch reactor.
14. Define space time and space velocity.
15. State the general rules to be followed for best arrangement of a set of ideal reactors.
16. List the characteristics of tracer.
17. What are the two extremes of aggregation of fluid?
18. What are the three rate controlling steps assumed in the shrinking core model for gas-solid reactions?
19. What are the advantages of slurry reactors over fixed beds?
20. What is the significance of thiele modulus?

PART C (5 x 14 = 70 Marks)

21. a) (i) A human being of 75 kg consumes about 6 MJ of food per day. Assume that the food is all glucose and that the overall reaction is

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O,\ -\Delta H_r = 2.816\ MJ \qquad (7)$$

Find man's metabolic rate in terms of moles of oxygen used per m^3 of person per second.

(ii) For the reaction stoichiometry, A + B → C, find the reaction order with respect to A and B.

C_A	4	1	1
C_B	1	1	8
$-r_A$	2	1	4

(7)

(OR)

b) (i) Experiment shows that the homogeneous decomposition of ozone proceeds with a rate $-r_{O3} = k\,[O_3]^2\,[O_2]^{-1}$. Suggest a two-step mechanism to explain this rate and state how you would further test this mechanism. (7)

(ii) Milk is pasteurized if it is heated to 63°C for 30 min. But, if it is heated to 74°C, it only needs 15 s for the same result. Find the activation energy of this process. (7)

22. a) (i) Enzyme E catalyzes the transformation of substrate S to product P as follows: S + E → P +E, $-r_A = 200C_AC_{E0}/(2+C_A)$ mol/(l.min). If we introduce enzyme (C_{E0} = 1 mM) and reactant (C_A = 10 M) into a batch reactor and let the reaction proceed, find the time needed for the concentration of reactant to drop to 0.025 M. Note that concentration of enzyme remains unchanged during the reaction. (7)

(ii) It is planned to run the reaction, A → B, in a batch reactor at the same catalyst concentration. Find the time needed to lower the concentration of A from 10 mol/l to 2 mol/l. The concentration of A C_A versus reaction rate $-r_A$ data is as follows: (7)

C_A, mol/l	1	2	4	6	7	9	12
$-r_A$, mol/(l.h)	0.06	0.10	0.25	1	2	1	0.5

(OR)

b) (i) The elementary liquid phase reaction A + 2B ←→ R with rate equation, $-r_A = -r_B/2 = 12.5C_AC_B^2 - 1.5C_R$ mol/l.min is to take place in a 6 l mixed flow reactor. Two feed streams one containing 2.8 mol A/l and the other containing 1.6 mol B/l, are to be introduced at equal volumetric flow rates into the reactor, and 75% conversion of limiting component is desired. What should be the flow rate of each stream? Assume a constant density throughout. (7)

(ii) A homogeneous gas phase reaction A → 3R has a reported rate at 215°C, $-r_A = 0.01C_A^{0.5}$ mol(l.s). Derive an expression for space time. (7)

23. a) Explain tank-in-series model for non-ideal conditions

(OR)

b) Derive the relationship between **C**, **E** and **F**.

24. a) The results of the kinetic runs on the reaction A → R, made in an experimental packed bed reactor using a fixed feed rate F_{A0} = 10 kmol/h are as follows.

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

Find the reaction rate at 40% conversion.

(OR)

b) Derive expressions for shrinking core model applicable to spherical particles of unchanging size.

25. a) Explain the construction, working, applications, merits and demerits of fluidized bed bioreactor with a neat sketch.

(OR)

b) Explain in detail the gas-liquid reactions on solid catalysts with examples from biological engineering.

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