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KUMARAGURU college of technology
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B.TECH DEGREE EXAMINATIONS: MAY 2018

(Regulation 2015)

Sixth Semester

BIOTECHNOLOGY

U15BTT601 : Chemical Reaction Engineering

COURSE OUTCOMES

CO1: Revise the basic laws on chemical kinetics and their applications in reactions.
CO2: Compare the various ideal reactors and their design equations
CO3: Describe the non-ideal behaviour of reactors and their models
CO4: Explain the kinetics for heterogeneous reacting systems
CO5: Outline the G/L reactions on solid catalysts.
CO6: Compare the various multiphase reactors and their applications in bioprocess industries

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

Answer all the Questions
PART A (10 x 1 = 10 Marks)

1. Consider the following properties: CO1 [K_2]
   1. Temperature
   2. Pressure
   3. Momentum
   4. Mass
   5. Energy

   Which of these depends upon rate of biochemical reaction?

   a) 1,2 b) 2,3

   c) 3,4 d) 4,5

2. Consider the following for transition complexes: CO1 [K_2]

   1. Termination

   2. Propagation

   3. Initiation

   Which is the correct sequence for photo synthesis chain reactions?

   a) 1-2-3 b) 2-3-1

   c) 3-2-1 d) 1-3-2

3. **Assertion (A)**: Unsteady-state operation is where composition does not change with time and at any instant the composition throughout the reactor is non uniform. CO2 [K_3]

   Reason (R): In the batch microbial reactor, the substrates are initially charged into a vessel, are well mixed and are left to react for a certain period. The product is then discharged.

a) Both A and R are individually true and R is the correct explanation of A

b) Both A and R are individually true but R is not the correct explanation of A

c) A is true but R is false

d) A is false but R is true

4. In a recycle bioreactor the recycle ratio is zero. This means the reactor is basically a CO2 [K_2]

a) Plug Flow Reactor

b) Continuous Stirred Tank Reactor

c) PFR with radial mixing

d) PFR with substantial axial dispersion

5. Match the (Dispersion coefficient D) column I with the appropriate process in column II. CO3 [K_3]

Column I		Column II	
A	D > 0	1	Moderate
B	D < 0	2	Rapid spreading
C	D = 0	3	Slow spreading
D	D > 0 < 0	4	No spreading

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-4, D-1

c) A-3, B-4, C-1, D-2

d) A-4, B-1, C-2, D-3

6. **Assertion (A)**: Major use of the residence time distribution in a fermenter to characterize non-ideal behavior is to diagnose problems of fermenter in operation and to predict conversion in existing/available fermenter. CO3 [K_2]

Reason (R): The basic ideas that are used in the distributions of residence time to characterize and model non-ideal bioreactions are really few in number.

a) Both A and R are individually true and R is the correct explanation of A

b) Both A and R are individually true but R is not the correct explanation of A

c) A is true but R is false

d) A is false but R is true

7. Match the terms in column I with the appropriate definitions given in column II CO4 [K_1]

Reactors		Rates	
A	Differential (flow) reactor	1	$\frac{t}{C_{A0}} = \int_0^{X_A} \frac{dX_A}{-r_A} = \frac{V}{W}\int \frac{dX_A}{-r'_A}$
B	Drug flow in vains	2	$-r'_A = \frac{dX_A}{dW/F_{A0}} = \frac{dX_A}{d(W/F_{A0})}$
C	Wine fermenter	3	$\frac{W}{F_{A0}} = \int_0^{X_A} \frac{dX_A}{-r'_A}$
D	Curd making vessel	4	$-r'_{Aout} = \frac{F_{A0}X_{Aout}}{W}$

a) A-1, B-2, C-3, D-4

b) A-2, B-3, C-4, D-1

c) A-3, B-4, C-1, D-2

d) A-4, B-1, C-2, D-3

8. Consider the flow patterns involved in the heterogeneous system: CO4 [K_3]

1. Mixed flow
2. Cross current
3. Counter current
4. Co current

Which are these flow patterns most suitable for high pressure gas phase reaction in the lungs for O_2 transfer?

a) 1,2 b) 2,3

c) 3,4 d) 4,1

9. Consider the following for the conversion of A carried out over a solid catalyst: CO5 [K_3]

1. Transport from the interface, through the liquid film, to the bulk liquid.
2. Transport from the bulk liquid to external catalyst surface through the liquid film surrounding the catalyst particle.
3. Diffusion and reaction within the porous catalyst particle.
4. Transport from the bulk gas phase to the gas-liquid interface through the gas film.

Which is the correct sequence for reactant A involved in the overall reaction process?

a) 1-2-3-4 b) 2-3-4-1

c) 3-4-1-2 d) 4-1-2-3

10. Which one of the fluid-particle reactors is operated at semi batch in and enzymatic reaction? CO6 [K_2]

a) Rotary dryer for heat-sensitive material b) Fluidized-bed reactor

c) Blast furnace d) Ion exchange bed

PART B (10 x 2 = 20 Marks)
(Answer not more than 40 words)

11. From the chemical reaction A $\xrightarrow{k}$ B an increase in temperature from 295 K to 305 K causes the rate of reaction to double. Calculate the energy of activation for this reaction. CO1 [K_4]

12. A reaction has the stoichiometric equation A + B→2R. What is the order of reaction? CO1 [K_3]

13. Distinguish between Holding time and Space time for flow reactors with expression. CO2 [K_3]

14. Define autocatalytic reactions. CO2 [K_2]

15. What are the causes of non-ideality in reactors? CO3 [K_3]

16. Mention the different types of inputs in the bioreactors interpreted for experiment. CO3 [K_2]

17. Recite the some examples of catalytic and non-catalytic heterogeneous bioreactions. CO4 [K_2]

18. What is meant by flux? CO4 [K_2]

19. Define Effectiveness factor. CO5 [K_2]

20. Write short note on multiphase bioreactor. CO6 [K_2]

Answer any FIVE Questions
PART C (5 x 14 = 70 Marks)
(Answer not more than 300 words)

Q.No. 21 is Compulsory

21. A sample of the tracer (sodium) at 320 K was injected as a pulse to a bioreactor, and the effluent concentration was measured as a function of time, resulting in the data shown in Table. CO3 [K_5]

t (min)	0	1	2	3	4	5	6	7	8	9	10	12	14
C(g/m^3)	0	1	5	8	10	8	6	4	3.0	2.2	1.5	0.6	0

The measurements represent the exact concentrations at the times listed and not average values between the various sampling tests. Construct figures showing C(t) and E(t) as functions of time.

22. Derive an expression for irreversible bimolecular-type second-order reactions with graph. CO1 [K_5]

23. Enzyme E catalyses the fermentation of substrate A to product R. Find the size of mixed flow reactor needed for 95% conversion of substrate in a feed stream (25 liter/min) of substrate (2 mol./liter) and enzyme. The kinetics of the fermentation at this enzyme concentration are given by CO2 [K_5]

$$A \xrightarrow{\text{enzyme}} R, \qquad -r_A = \frac{0.1\,C_A}{1 + 0.5\,C_A} \ \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

24. Consider a single cylindrical pore in a lung alveoli. Derive the pore diffusion resistance of oxygen combined with surface kinetics. CO4 [K_5]

25. Explain in detail about the progressive core model and shrinking core model by taking a biological example. CO5 [K_2]

26. Aqueous fructose at a concentration C_{AO} = 1 mol./liter is introduced into a batch bioreactor where it reacts away to form glucose according to stoichiometry A→R by glucose isomerase. The concentration of fructose in the reactor is monitored at various times, as shown below CO1 [K_5]

t, min	0	100	200	300	400
C_A, mol./m^3	1000	500	333	250	200

For C_{AO} = 500 mol./m^3 find the conversion of fructose after 5 hours in the batch bioreactor

27. Outline the working and principle applications of following reactors with neat a sketch. CO6 [K_2]
    (i) Trickle bed reactor (7)
    (ii) Slurry reactor (7)

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