Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IISEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, APRIL 2018 (REGULAR)

BIO5221- BIOREACTOR DESIGN AND ANALYSIS

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A.	Write the various reaction rate expressions used for Homogeneous and heterogeneous reaction systems	**3**
1B.	Explain the external film mass transfer effects in immobilized enzyme reaction system. Develop a suitable expressions for estimation of interfacial substrate concentration and film effectiveness factor for Michaelis-Menten kinetics.	**4**
1C	Isomerization of Glucose to Fructose by immobilized glucose isomerase was carried out in a fixed bed bioreactor. The enzyme was immobilized on non-porous glass beads of 2mm diameter. The substrate (S0=2 M) is pumped from the bottom of the reactor at volumetric flow rate of 8ml/min. At this flow rate Damkholar number obtained as 1.25. The intrinsic rate without mass transfer resistance is obtained as 0.085 M/min. Find the film effectiveness factor in the above reaction system. Data: Vmax=0.0281 M/min, Km=0.231 M	**3**
2A.	What do you mean by constant feed rate policy in the operation of immobilized enzyme reactor system? Develop a suitable model for predicting the time course profiles of conversion due to enzyme deactivation for Zero order kinetics, no pore diffusion effects in packed bed bioreactor that behaves like PFR.	**5**
2B.	A fluidized-bed, immobilized-cell bioreactor is used for the conversion of glucose to ethanol by *Z. mobilis* cells immobilized in k-carrageenan gel beads. The dimensions of the bed are 10cm (diameter) by 200 cm. Since the reactor is fed from the bottom of the column and because of CO_2 gas evolution, substrate and cell concentrations decrease with the height of the column. The average cell concentration at the bottom of the column is X_0 = 45 g/l, and the average cell concentration decreases with the column height according to the following equation: $X = X_0(1 - 0.005Z)$ where Z is the column height (cm). The specific rate of substrate consumption is q_S = 2 g S/g cells. h. The feed flow rate and glucose concentration in the feed are 5 L/h and 160 g glucose/l, respectively. a. Determine the substrate (glucose) concentration in the effluent. b. Determine the ethanol concentration in the effluent and ethanol productivity (g/l .h) if $Y_{P/S}$ = 0.48 g ethanol/g glucose.	**5**
3A.	Penicillin is produced by *P.chrysogenum* in a fed-batch culture with the intermittent addition of glucose solution to the culture medium. The initial	**5**

	culture volume at quasi-steady state is V_0 = 500 L, and glucose-containing nutrient solution is added with a flow rate of v_0 = 50 L/h. Glucose concentration in the feed solution and initial cell concentration are S_0 = 300 g/l and X_0 =20 g/l, respectively. The kinetic and yield coefficients of the organism are μ_m = 0.2 h^{-1} K_S = 0.5 g/l, and $Y_{X/S}$ = 0.3 g dw/g glucose. a. Determine the culture volume at t = 10 h. b. Determine the concentration of glucose at t = 10 h at quasi-steady state. c. Determine the concentration and total amount of cells at quasi-steady state when t = 10 h. d. If q_P = 0.05 g product/g cells.h and P_0 = 0.1 g/l, determine the product concentration in the vessel at t = 10 h.	
3B	Butyric acid is produced using *Clostridium butyricum* in a Chemostat under sterile environment with glucose as the substrate, S_0=4 g/l at dilution rate of D=0.49 h^{-1}. Steady state substrate and biomass concentrations are 1.5 and 1.0 g/l respectively. Assume that growth follows the Monod's kinetics with, μ_m=0.53 h^{-1}, Ks=0.12 M and Y=0.4. The following material balance equations are obtained for biomass(X) and substrate (S) in the above continuous operation of Chemostat. Biomass balance: $\frac{dX}{dt} = (\mu - D)X$ –(1) Substrate balance: $\frac{dS}{dt} = D(S0 - S) - \frac{\mu X}{Y}$ --(2) Y=yield factor, μ =specific growth rate, D=dilution rate i. Find the elements of the A matrix in the linearized equations that are obtained using Taylor series expansion. ii. Find the Eigen values and discuss on stability of above fermenter	**5**
4A.	Lactic acid is produced using *Lacto bacillus* in a Chemostat under sterile environment with glucose as the substrate, S_0=4 g/l at dilution rate of D=0.3 h^{-1}. Steady state substrate and biomass concentrations are 1.5 and 1.0 g/l respectively. Assume that growth follows the Monod's kinetics with, μ_m=0.53 h^{-1}, Ks=0.12 g/l and Y=0.4 I. Find the controllability matrix for the above system II. Do you feel that above system is controllable?	**5**
4B.	What do you mean by Nutristat operation of continuous fermenter? Design the P-controller for Nutristat operation of continuous fermentation process.	**5**
5A.	The following data were obtained from a non-ideal bioreactor during the RTD experiment using NaCl as the tracer material. Determine the (i) Average residence time (ii) dispersion number (iii) plot E(θ) vs θ (iv) Find the fraction of material coming out from the reactor in the time interval 290 and 450 s.	**5**

Time, S	0	120	240	360	480	600	720	840	960
Tracer concentration g/cc	0	6.5	12.5	12.5	10.0	5.0	2.5	1.0	0.0

5B.	Explain the various tracer inputs signals generally used in RTD experiment	**2**
5C	Explain: CIP, COP, SIP of cleaning and sterilization procedures in fermenters	**3**