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# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*(A constituent unit of MAHE, Manipal)*

## IISEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)

## END SEMESTER EXAMINATIONS, APRIL 2019 (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.** | How do you define reaction rate in<br>i. Homogeneous reaction system<br>ii. Heterogeneous reaction system | **3** |
| **1B.** | Write on the various dimensionless numbers that are used in estimating (i) External Mass transfer effects (ii) Internal mass effects (ii) Simultaneous internal and external mass transfer effects. | **4** |
| **1C** | Hydrolysis of Rice bran oil is carried out in a CSTR with free Lipase enzyme. The substrate ($S_0$=4M) is pumped at 0.1 L/min. Find the volume of the reactor to achieve 65% conversion at steady state for the following kinetics<br>i. Substrate inhibition kinetics<br>ii. Product inhibition kinetics<br>Kinetics data: $V_m$=0.028 M/min, $K_M$=0.23 M, $K_I$=0.2 M, $P_0$=0 | **3** |
| **2A.** | Consider a 1000 liter Chemostat in which biomass is being produced with glucose as the substrate. The microbial growth follows a Monod relationship with $\mu_m$ = 0.4 $h^{-1}$, $K_S$ = 1.5 g/l, and the yield factor $Y_{x/s}$=0.5. If normal operation is with a sterile feed containing 10 g/l glucose at a rate of 100 liter/h: What is the specific biomass production rate (g/l-h) at steady state? If recycle is used with a recycle stream of 10 liter/h and a recycle biomass concentration five times as large as that in the reactor exit, what would be the new specific biomass production rate? | **5** |
| **2B.** | 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 M-M kinetics, no pore diffusion effects in packed bed bioreactor (PFR). | **5** |
| **3A.** | The data Shown below are the fractional conversions of substrate(X) obtained for the hydrolysis of benzoyl-arginine ethyl ester (BAEE) by the enzyme ficin immobilized to CM-.cellulose. The immobilized enzyme was packed in a column (plug-flow) reactor, and the data were obtained for different flow rates ($V_0$) through the column, and substrate concentrations (So). Estimate the Michaelis constant for the hydrolysis of BAEE and comment on the results. | **5** |

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|---|---|---|

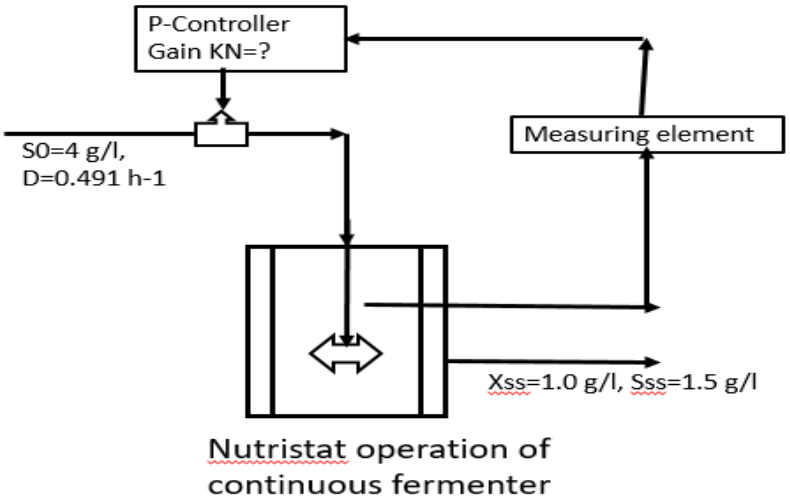
| $V_0$ (ml/h) | Substrate Concentration ,So (mM) | | | | |
|---|---|---|---|---|---|
| | 2.0 | 6.0 | 20.0 | 33.0 | 55.0 |
| 40 | X=0.36 | 0.33 | 0.26 | 0.22 | 0.16 |
| 80 | X=0.30 | 0.27 | 0.17 | 0.13 | 0.095 |
| 140 | X=0.27 | 0.22 | 0.12 | 0.087 | 0.061 |

**3B** Write the elements of A-matrix during Wash out unstable operation of Chemostat. Find the Eigen values for Biomass and Substrate and based their signs prove that system is unstable. **5**

**4A.** Gluconic acid is produced using *Pseudomonas species* in a Chemostat under sterile environment with glucose as the substrate, $S_0$=2 g/l at dilution rate of D=0.433 $h^{-1}$. Steady state substrate and biomass concentrations are 2.5 and 4.5 g/l respectively. Assume that growth follows the Monod's kinetics with, $\mu_m$=0.45 $h^{-1}$, Ks=0.1 g/l and Y=0.52 **5**

I. Find the controllability matrix for the above system
II. Do you feel that above system is controllable?

**4B.** Lactic acid is produced using *Lactococcus lactis* in a Chemostat under sterile environment with glucose as the substrate, $S_0$=4 g/l at dilution rate of D=0.491 $h^{-1}$. Steady state substrate and biomass concentrations are 1.5 and 1.0 g/l respectively. Assume that growth follows the Monod's kinetics with, $\mu_m$=0.53 $h^{-1}$, Ks=0.12 g/l and Y=0.4. It is desired control the substrate concentration at its steady state value by manipulating the dilution rate of feed. **5**



Nutristat operation of continuous fermenter

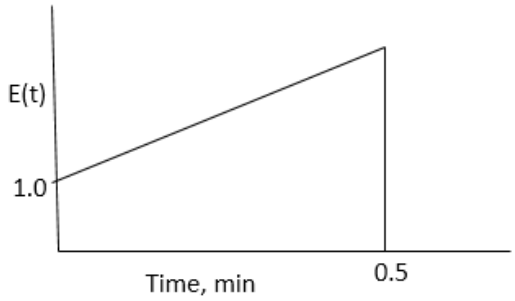
i. Find the [A-B$K_N$] matrix for the above process
ii. Find the suitable $K_N$ value that stabilizes the process in the case of disturbances

**5A.** The following data were obtained from a non-ideal bioreactor during the RTD experiment using NaCl as the tracer material. Calculate **4**

i. The mean residence time of fluid in the bioreactor
ii. Draw the E (θ) curve

RTD data:

| Time (min) | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
|---|---|---|---|---|---|---|---|---|
| Tracer conc. (g/l) | 0 | 3 | 5 | 5 | 4 | 2 | 1 | 0 |

| | | |
|---|---|---|
| **5B.** | A macro fluid reacts according to A $\rightarrow$ R as it flows through a non-ideal bioreactor. Find the conversion of macro fluid A for the following flow pattern and kinetics.<br>Kinetics: $C_{A0}$=2 mol/liter, $-r_A=KC_A^2$, K=2 liter.mol$^{-1}$ min$^{-1}$<br>  <br> | **3** |
| **5C** | Write on following operating issues that affects the designing of bioreactor<br>i. Heat transfer.<br>ii. Foaming | **3** |