Birla Institute of Technology and Science,
Pilani – Pilani Campus Semester-II, 2021-22

Comprehensive Examination (Regular)
CHE F421: Biochemical Engineering

Date: 10/05/2022 **Duration:** 3 Hr. **Max. Marks:** 80

CLOSED BOOK (30 marks; 1 Hour 15 minutes)

1) What is the purpose of sensors in bioreactors. Write down their principle of operation. [3 M]

2) Write a short note on bio-product regulation. [3 M]

3) Explain different types of chromatography techniques for separation and purification of products. [3 M]

4) Explain various cell disruption methods. [3 M]

5) What is a mixed culture. What are the major interactions between organisms for mixed cultures. Explain any three. [3 M]

6) What are the different types of resistance encountered in a cake filtration. Derive an expression for the relationship between the volume of filtrate (V) and time (t) for the cake filtration process. [7 M]

7) Derive an expression for cell residence time and hydraulic residence time for a activated sludge process. Also determine the required volume of an activated-sludge tank for a certain degree of BOD removal. [8 M]

Open Book (50 marks; 1 Hour 45 Minutes)

1) Pesticide inhibition on an active enzyme has been reported, which caused enzyme activities to reduce. The collected data with and without inhibition are presented in Table. Determine the kinetic parameters with and without inhibitor. Also define the type of inhibition. [10 M]

S (mol l^{-1})	**v (no inhibitor) (mol l^{-1} min^{-1} × 10^6)**	**v* (inhibitor) (mol l^{-1} min^{-1} × 10^6)**
3.30×10^{-4}	56	37
5.00×10^{-4}	71	47
6.70×10^{-4}	88	61
1.65×10^{-3}	129	103
2.21×10^{-3}	149	125

2) Monod rate model is valid for a CSTR bioreactor with maximum specific growth rate of 0.5 h^{-1} with and K_s = 2 g l^{-1}. What would be the suitable dilution rate under steady-state conditions, where there is no cell death and if initial substrate concentration is 50 g $l^{-1}$and yield of biomass on substrate is 100%. [8 M]

3) A simple, batch fermentation of an aerobic bacterium growing on methanol gave the results shown in the table. Calculate:
   a. Maximum growth rate (μ_{max})
   b. Yield on substrate ($Y_{X/S}$)
   c. Mass doubling time (t_d)
   d. Saturation constant (K_s)
   e. Specific growth rate (μ_{net}) at t = 10 h [10 M]

Time (h)	X (g/l)	S (g/l)
0	0.2	9.23
2	0.211	9.21
4	0.305	9.07
8	0.98	8.03
10	1.77	6.8
12	3.2	4.6
14	5.6	0.92
16	6.15	0.077
18	6.2	0

4) Suppose you have a microorganism that obeys the Monod equation. The value of μ_{max}= 0.7 hr^{-1} and K_S = 5 g/L. The cell yield ($Y_{X/S}$) is 0.65. You want to cultivate this microorganism in either one fermenter or two in series. The flow rate and the substrate concentration of the inlet stream should be 500 L/hr and 85 g/L, respectively. The substrate concentration of the outlet stream must be 5 g/L.

a. If you use one CSTR, what should be the size of the fermenter? What is the cell concentration of the outlet stream?

b. If you use two CSTRs in series, what sizes of the two fermenters will be most productive. What are the concentration of cells and substrate in the outlet stream of the first fermenter? (Hint: use optimum parameters for first fermentor for maximum productivity)

[12 M]

5) For the activated-sludge unit, the specific growth rate of cells is given by

$$\mu_{net} = \frac{\mu_m S}{K_s + S} - k_d$$

The following parameter values are known: F = 500 1/h, α = 0.4, γ = 0.1, X_e = 0, V = 1500 l, K_s = 10 mg/l, μ_m = 1 h^{-1}, k_d = 0.05 h^{-1}, S_0 = 1000 mg/l, $Y^M_{X/S}$ = 0.5 g dw/g substrate.

a. Calculate the substrate concentration (S) in the reactor at steady state.

b. Calculate the cell concentration(s) in the reactor.

c. Calculate X_r and S_r in the recycle stream. [10 M]