

Bachelor of Engineering in Chemical Engineering Examination, 2017
4th Year, 1st Semester
Bioprocess Engineering

Time: 3 hours

Total Marks:100

Answer any five questions.

Use graph paper if require. Assume any missing data.

1.	Glucose is converted to ethanol by immobilized yeast cells entrapped in gel beads. The specific rate of ethanol production, $q_p = 0.2 \text{ g ethanol/g cell-h}$. The effectiveness factor for an average bead is 0.8. Each bead contains 50g/L of cells. The voidage of the bed is 40%. Assume growth to be negligible (all glucose is converted to ethanol). The feed flow rate is 400L/h and the feed concentration of glucose is 150g/L. The diameter and the height of the column are 1m and 4m respectively and the yield coefficient is 0.49g ethanol/g glucose. What is the exit concentration of glucose? What is the concentration of ethanol in the exit stream? Show all relevant derivations.	20
2.a)	Clarified bioreactor broth contains a protein at a concentration of 10g/L. Product is harvested from the broth using ultrafiltration at a fluid velocity of 0.34m/s in open membrane tubes of diameter 24mm and length of 2m. Deriving the necessary equation, estimate the permeate flux if the filter is operated under gel polarization condition and protein concentration in the gel is 20 g/L. The properties of bioreactor broth: $\rho = 1020 \text{ kg/m}^3$; $\mu = 1.8 \text{ cP}$; $D = 3.6 \times 10^{-11} \text{ m}^2/\text{s}$. $[N_{Sh} = 0.023(N_{Re})^{0.89}(N_{Sc})^{0.3}]$	11
2.b)	Define allosteric enzymes.	3
2.c)	Develop the mathematical model for a bubble column bioreactor stating all assumptions	6
3.a)	An enzyme is used for the production of a compound used in the preparation of sunscreen lotion. The enzyme deactivates with a half-life of 4h. What time will be required for 80% conversion if the initial substrate concentration, v_{max0} and K_m be 12mM, 9mM/h and 8.9mM respectively?	8
3.b)	Estimate the fraction of plasmid containing cells in a batch culture if the cells are maintained at constant specific growth rate of 0.693 h^{-1} during scale up from flask to production fermenter. Total time: 20h; Inoculum: 100% plasmid containing cells. μ (specific growth rate of plasmid free cells) = 0.97 h^{-1} ; $p = 0.001$. Show all derivations.	12
4.	A new strain of yeast is being used for biomass production. The following data were obtained from a CSTBR under steady state. An influent substrate concentration of 700mg/L was used. Considering endogenous growth, calculate μ_{max} , K_s , $Y_{X/S}^M$, k_d and m_s . Show all derivations.	20

D(h ⁻¹)	0.1	0.2	0.3	0.4	0.5	0.6	0.7
C _s (mg/L)	16	33	59	101	169	298	702
C _x (mg/L)	366	407	408	404	371	299	59

5	<p><i>Saccharomyces cerevisiae</i> is grown anaerobically in continuous culture at 30 °C. Glucose is used as carbon source, ammonia is the nitrogen source. A mixture of glycerol and ethanol is produced. At steady state, mass flows to and from the reactor at steady state are as follows: Glucose: 36 kg/hr; NH₃ : 0.4 kg/hr, cells out: 2.81 kg/hr, glycerol out : 7.94 kg/hr; ethanol out: 11.9 kg/hr; CO₂ out: 13.6 kg/hr; water out: 0.15 kg/hr. Estimate the cooling requirements. Assumptions are: steady state, homogeneous, heat of combustion of yeast is - 21.2 KJ/kg; ideal solution, no evaporation and no shaft work. Mol wt of glucose: 180, ammonia: 17; glycerol: 92; ethanol: 46 and its corresponding heats of combustion are: glucose: -2805 KJ/gmol; ammonia:-382.6 KJ/gmol; glycerol: -1655.4 KJ/gmol; ethanol : -1366.8 KJ/gmol respectively.</p>	20
6	<p>A marine microorganism contains an enzyme that hydrolyzes glucose-6-sulfate (S). The assay is based on the rate of glucose formation. The enzyme in a cell-free extract has kinetic constants of $K_m=6.1 \times 10^{-4}$ M and $V_{max} = 300$ nmoles x lt⁻¹x min⁻¹. Galactose - 6 - sulfate is a competitive inhibitor (I). At 10^{-5} M galactose - 6 - sulfate and 2×10^{-5} M glucose-6-sulfate, v was 1.5 nmole x lt⁻¹xmin⁻¹. Calculate K_i for galactose - 6- sulfate.</p> <p>Briefly describe Animal cell culture reactor.</p>	14 6
7	<p>Design a low rate filter reactor to treat 6 ML/d of wastewater of BOD of 200mg/L. The final BOD after treatment should be 30 mg/L and organic loading rate is 320 g/m³/d. Depth of filter is 1.5 m.</p> <p>Briefly describe the competitive inhibitor enzyme reaction.</p>	10 10
8	<p>Write down the application of enzyme in detergent and medical purpose</p> <p>Glucose isomerase is used extensively for production of high fructose syrup. The reaction is glucose to fructose. Heat of reaction is 5.73 KJ/gmole. Entropy of reaction is 0.017 KJ/gmole/K. Calculate the equilibrium constant at 50°C and 75°C.</p>	12 8