Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

II SEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, MAY 2016

SUBJECT: BIOPROCESS MODELLING ANALYSIS AND SIMULATION

[BIO 504]

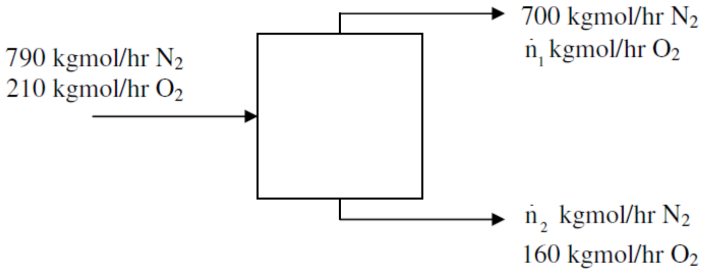
REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitable assumed.

1A.	Define briefly all the steps involved in modeling a process with a neat block diagram	**3M**
1B.	Differentiate between White box and Black box models with an example.	**2M**
1C.	A square tank, 4m on a side and 10 m height is filled with brim of water. Tank has a 5 cm^2 hole at the bottom which is suddenly opened. Derive the dynamic model of the system and find the time required for draining the tank completely, if the flow rate through the hole is given by $F = 0.62A(2gh)^{1/2}$, where A is area of hole and 'h' is height of water at any time 't'.	**5M**
2A.	Two species A and B are present in both inlets. In reactor, A + B --------→ P. Feed 1 and Feed 2 contains concentrated and dilute feed respectively. The flow rate of concentrated feed is F_1 (m^3/min), dilute feed is F_2 (m^3/min) and for Outlet is F (m^3/min). Concentration C_{A1}, C_{B1} are in concentrated feed (inlet 1) and C_{A2}, C_{B2} are in dilute feed (inlet 2). In reactor and outlet, the concentrations are C_A, C_B and C_P. Assume perfect mixing. Reaction rate equation given; $r = k_1C_B/(1+k_2C_B^2)$; So rate depend on B only, as A is the excess reactant. Develop model for the rate of change of concentration of B in the tank and rate of change of height of liquid in the tank.	**5M**
2B.	A 150m^3 bioreactor is operated at 35^oC to produce fungal biomass from glucose. The rate of oxygen uptake by the culture is 1.5 kg m^{-3} h^{-1}; the agitator dissipates heat at a rate of 1 kW m^{-3}. 60 m^3 h^{-1} cooling water available from a nearby river at 10^oC is passed through an internal coil in the fermentation tank. If the system operates at steady state, what is the exit temperature of the cooling water?	**5M**
3A.	An equilibrium distillation is charged with 20 kmol of bio-ethanol and its composition is same as feed stream. The composition of feed entering is 0.32 mole fraction of bio-ethanol with a flow rate of 10 kmol/hr. Stream leaving at the same rate. α = relative velocity of ethanol and water mixture (2.48), Y_D = mole fraction of ethanol in vapor phase, X_W = mole fraction of ethanol in liquid phase. $Y_D = \alpha X_W/(1+ (\alpha-1) X_W)$. Estimate time required for composition of overall product to fall to 0.4 mole fraction.	**5M**

3B.	Hydrogen can be produced using a process called coal gasification. It is desired to supply nearly pure oxygen to this process. Oxygen is separated from nitrogen out of the air (79 mol% nitrogen and 21 mol% oxygen) via a process known as cryogenic distillation. A cryogenic distillation unit has a feed of 1000 kgmol/hr air. The top stream has 700 kgmol/hr nitrogen and the bottom stream has 160 kgmol/hr oxygen. The process is illustrated in the block diagram below. Write balances on the oxygen and nitrogen to determine the unknown component molar flow rates. 	**5M**
4A.	A ventilation system has been designed for a large laboratory with volume of 1100 m^3. The volumetric flow rate of ventilation is 700 m^3/min at 22°C and 1 atm pressure. The later values may also be taken as that of room air. A reactor in the laboratory is capable of emitting as much as 1.5 moles of SO_2 into the room. If a seal ruptures and SO_2 mole fraction in the room air > 1 ppm constitutes health hazard. Suppose the reactor seal ruptures at time t=0 and maximum amount of SO_2 is emitted almost instantaneously assuming that air flow is sufficient to make the room air composition spatially uniform. Calculate the concentration of SO_2 (moles/l) in the room 2 minutes after the rupture occurs and also the time required for the SO_2 concentrate in the room to reach level of safety.	**5M**
4B.	Develop a general expression for mass balance of Biomass in batch and fed-batch reactor operation.	**5M**
5A	In a chemostat you know that if a culture obeys the Monod equation, the residual substrate is independent of the feed substrate concentration. You observe that in your chemostat an increase in S_0 causes an increase in the residual substrate concentration. Your friend suggests that you consider whether the contois equation may describe the situation better. The Contois equation is $\mu = \frac{\mu_m S}{K_{sx} X + S}$ a. Derive an expression for S in terms of D, μ_m, K_{sx} and X for a steady state CFSTR. b. Derive an equation for S as a function of S_0, D, K_{sx} , Y_{xs} and μ_m. c. If S_0 increases two fold, by how much will S increase?	**5M**
5B	Develop structured-segregated metabolic model with a suitable example and also list the assumptions made.	**5M**
6A	Consider a stirred tank with fluid flowing in at a known volumetric flow rate (Note that there is a change in rate F_1 and F_2, rates can be a function of time, and need not be constant). Consider the height of liquid in tank, z. Develop a dynamic model and calculate the height of the tank after 1 min and 2 min using following data: F_1 = B sinαt + C; F_2 = 0.27 m^3/min, A = 0.9 m^2, z = 30 m, B = 0.27 m^3/min, C = 0.27 m^3/min and α = 0.1 m^3/min. Assume that density changes are constant. Use Runge Kutta 4th Order method.	**5M**
6B	The heat capacity of CO_2 is given as a function of temperature as follows: $C_p = 1.716 - 4.25 \times 10^{-6} T - 15.04/\sqrt{T}$. Determine the temperature which yields a value of heat capacity of 1 kJ/kg K. Use bisection method for five iterations. Initial condition: T_1 = 400 K and T_2 = 600 K.	**5M**