MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)
END SEMESTER EXAMINATION, JUNE 2022
SUBJECT: BIOPROCESS MODELLING ANALYSIS AND SIMULATION(BIO 5251)
REVISED CREDIT SYSTEM
ANSWER ALL QUESTIONS

TIME: 2:00 PM-5:00 PM **DATE: 23/06/2022** **MAX. MARKS: 50**

Q. NO	QUESTIONS	MARKS	CO	BTL
1A	Define a model. Describe briefly all the steps involved in modeling a process.	5	1	2
1B	List the advantages and disadvantages of mathematical modelling of a process.	3	1	2
1C	Differentiate between macroscopic and microscopic systems.	2	1	2
2A	A well-stirred batch reactor wrapped in an electrical heating mantle is charged with a liquid reaction mixture. The reactants must be heated from an initial temperature of 25 °C to 250 °C before the reaction can take place at a measurable rate. Use the data given below to determine the time required for this heating to take place. ○ Reactants: Mass = 1.50 kg, C_v = 0.900 cal/g °C ○ Reactor: Mass = 3.00 kg, C_v = 0.120 cal/g °C ○ Heating rate: Q = 500.0 W ○ Negligible reaction and no phase changes during heating. ○ Negligible energy added to the system by the stirrer.	4	2	4,5
2B	A dilute solution at 20 ºC is added to a well-stirred tank at the rate of 180 kg/hr. A heating coil having an area of 0.9 m^2 is located in the tank and contains steam condensing at 150 ºC. The heated liquid leaves at 120 kg/hr and at the temperature of the solution in the tank. There is 500 kg of solution at 40 ºC in the tank at the start of the operation. The overall heat-transfer coefficient is 342 kg/hr m^2 ºC and the heat capacity of water is 1 kcal/kg ºC. Calculate the (i) outlet temperature after 1 hr, and (ii) steady state temperature.	4	2	4,5
2C	Malonic acid and water are initiallybat 25 °C. If 15 g malonic acid is dissolved in 5 kg water, how much heat must be added for the solution to remain at 25 °C? What is the solution enthalpy relative to the components? Data: The molecular weight of malonic acid is 104.	2	2	3

	Δh_m at 25 °C = 4.493 kcal/gmol.			
3A	A bioreactor contains 3 m^3 of pure oxygen at atmospheric pressure. Air is slowly pumped into the bioreactor and mixes uniformly with the contents, an equal volume of which is forced out of the tank. What is the concentration of oxygen in the tank after 9 m^3 of air has been admitted?	**5**	**3**	**4.5**
3B	A ventilation system has been designed for a large laboratory with a volume of 1100m^3. The volumetric flow rate of ventilation air is 700m^3 /min at 22 °C and 1 atm. (The latter two values may also be taken as the temperature and pressure of the room air.) A reactor in the laboratory is capable of emitting as much as 1.5 mol of sulphur dioxide into the room if a seal ruptures. An SO_2 mole fraction in the room air greater than $1x10^{-6}$ ppm constitutes a health hazard. Suppose the reactor seal ruptures at a time t =0, and the maximum amount of SO_2 is emitted and spreads uniformly throughout the room almost instantaneously. Assuming that the air flow is sufficient to make the room air composition spatially uniform, write a differential SO_2 balance. Calculate the concentration of SO_2 in the room two minutes after the rupture occurs.	**3**	**3**	**4,5**
3C	Consider a CSTR into which flows a liquid stream at a volumetric rate of F_o, (m^3/min) and with a density of ρ (kg/m^3). A consecutive reactions occur in the CSTR. Reactant A goes to B at a specific reaction rate K_1 , but B can react at a specific reaction rate K_2, to form a third component C. $A \xrightarrow{K1} B \xrightarrow{K2} C$ The volumetric holdup of liquid in the tank is V (m^3), and its density is ρ. The volumetric flow rate from the tank is F, and the density of the outflowing stream is the same as that of the tank's contents. Show the component continuity equation for components B and C.	**2**	**3**	**6**
4A	A 5 m^3 fermenter is operated continuously with feed substrate concentration 20 kg/m^3. The microorganism cultivated in the reactor has the following characteristics: μ_{max} = 0.45 h^{-1}, K_s = 0.8 kg/m^3, Y_{xs} = 0.55 kg/kg. i. What feed flowrate is required to achieve 90 % substrate conversion? ii. How does the biomass productivity at 90 % substrate conversion with the maximum possible?	**5**	**4**	**4,5**
4B	A feed stream containing glucose enters a fed-batch fermenter at constant flow rate. The initial volume of liquid in the fermenter is V_o. Cells in the fermenter consume glucose at a rate given by: $r_s = k_1*S$ Where k_1 is the rate constant (h^{-1}) and 'S' is the substrate concentration of glucose in the fermenter (g/L). i. Assuming constant density, develop a model for the total mass balance. What is the expression relating volume and time? ii. Develop a model for rate of change of substrate concentration.	**3**	**4**	**2,6**
4C		**2**	**4**	**4**

	During exponential phase in batch culture, the growth rate of culture is propotional to the concentration of cells present. When *streptococcus lactis* bacteria are cultured in milk, the concentration of cells doubles in 45 min. If this rate of growth is maintained for 12 h, what is the final concentration of cells relative to the inoculum level?			
5A	In a tubular reactor with axial dispersion, the reactor Peclet number (Pe_r) is related to the first and second moments of the Residence Time Distribution as: $$\frac{2}{Pe_r^2}[Pe_r - 1 + e^{-Pe_r}] = \frac{\sigma^2}{t_m^2}$$ For a particular experiment, $\sigma^2 / t_m^2 = 0.23$. Solve the above equation to obtain the value of Pe_r by using the successive- substitution method.. [Note: Initial conditions are 1 and 10; tolerance level 1 x 10^{-4}].	**5**	**5**	**3,5**
5B	It is desired to make 1000 kg mixed acid containing 60 % H_2SO_4, 32 % HNO_3 and 8 % water by blending with (i) the spent acid contains 11.3 % HNO_3, 44.4 % H_2SO_4, and 44.3 % H_2O, (ii) aqueous 90 % HNO_3, and (iii) aqueous 98 % H_2SO_4. All % are by mass. Calculate the quantities of each of the three acids required for blending. Use Gauss elimination method.	**5**	**5**	**4,5**

CO: Course Outcome; BLOOM TAXONOMY LEVEL: 1-Remember, 2-Understanding, 3-Application, 4-Analyzis, 5-Evaluation, 6-Creation