MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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V SEMESTER B.TECH. EXTERNAL EXAMINATIONS DEC/JAN 2021

SUBJECT: BIOPROCESS ENGINEERING [BIO 3152]

Date of Exam: 30/01/2021 Time of Exam: 2.00 PM – 5.00 PM Max. Marks: 50

Instructions to Candidates:

- Answer ALL the questions & missing data may be suitable assumed

1A.	In the mashing step in beer and whisky brewing, ground partially sprouted barley grain is suspended in liquid (called a wort) to allow the enzyme amylase to break down starch contained in the grain into sugars. The mashing step is carried out at warm temperature to speed up the sugar conversion process, but the enzyme also deactivates at high temperature. As a bioprocess engineer operating this brewing process, you are asked to find an optimal temperature and time. How will you model this process? What are the parameters in your model? What do you vary and what do you measure experimentally to estimate these parameters?	**4**
1B.	Aspirin inhibits glutamate dehydrogenase. Following Data have been obtained for the enzyme catalysed and inhibition reaction. Determine the kinetic constants, type of inhibition and K_I:	**4**
1C.	For a given enzyme catalyzed reaction, the Michaelis constant is 0.5 mM and the substrate concentration is 6.0 mM. What is the fractional saturation of the enzyme under these conditions?	**2**
2A.	Consider the sterilization of a sodium gluconate production medium in the holding section of a continuous sterilizer. Assuming constant temperature, the specific death rate constant of the contaminant is 20 s^{-1}. If the average residence time in the holding section is 10 seconds, calculate the Del factor for the following and explain the results. i. For Pe = 400 ii. For Pe = 400, assuming plug flow iii. For Pe = 100 iv. For Pe = 100, assuming plug flow	**4**
2B.	If a pilot sterilization were carried out in 10^7 dm^3 vessel with a medium containing 10^{14} organisms per cm^3 requiring a probability of contamination of 1 in 1000, What would be the Nabla factor?	**2**
2C.	A continuous sterilizer is constructed using a 21 m length of pipe of internal diameter 8 cm. Liquid medium in the pipe is maintained at 128°C using saturated steam. At this temperature, the specific death constant of the contaminating organisms is 340 h^{-1} and the density and viscosity of the medium are 1000 kg/m^3 and 0.9 cP respectively. The	**4**

Product (mmoles/min)	4.58	6.40	7.72	8.72	9.50
Substrate (mmoles)	3	5	7	9	11
Asprin (mmoles/min) I = 5 mmoles	3.66	5.12	6.18	6.98	7.60

	concentration of contaminants in the raw medium is 6.5 x 10^5 mL^{-1}. If sterile medium is required on the fermentation floor at a rate of 0.9 m^3/h, what is the frequency of contamination in the fermentation factory?	
3A.	A bacterium having doubling time of 10 min fills a cylindrical vessel completely in 3 hours. How much time will it take to fill half of the vessel?	**2**
3B.	An experiment was performed to determine the effect of fetal calf serum on the growth rate of cells of a hybridoma cell line (HBD1). The following results were obtained. In which medium do the cells grow fastest? Show working to support your answer.	**3**

Time, h	0	30	60	90	120	180	210
O.D @ Medium A	0.05	0.05	0.06	0.08	0.11	0.4	0.76
O.D @ Medium B	0.05	0.05	0.05	0.07	0.1	0.21	0.29

Time, h	240	270	300	330	360
O.D @ Medium A	0.9	0.99	1.05	1.15	1.2
O.D @ Medium B	0.38	0.52	0.8	1.0	1.05

3C. The growth of a microbial population is a function of pH and is given by the following equation: **5**

$$\mu_g = \frac{1}{X}\frac{dX}{dt} = \frac{\left(\mu_m \Big/ \left\{1 + \frac{H^+}{k_1}\right\} \right) S}{\left(K_s \Big/ \left\{1 + \frac{H^+}{k_1}\right\} \right) + S}$$

i. With a given set of experimental data (X and S versus t), describe how you would determine the constants μ_m, K_s, and k_1.

ii. How would the double reciprocal plot $1/\mu_g$ vs 1/S change with pH (H^+) concentration?

4A. **4**

The air supply to the fermenter was turned off for a short period of time and then restarted. A value of C* of 7.3 mg/L has been determined for the operating conditions. Use the tabulated measurements of dissolved oxygen (DO) values in the following table to estimate the oxygen uptake rate and the k_La in the system.

	Air off							
Time, min	-1	0	1	2	3	4	5	6
C, mg/L	4.5	4.5	3.9	2.29	2.3	1.8	1.3	0.9

	Air on										
Time, min	7	8	9	10	11	12	13	14	15	16	17
C, mg/L	0	1.2	20	2.5	2.8	3.4	4.0	4.2	4.25	4.3	4.4

4B. **4**

For the following data determine the k_La using gassing out method.

Time, s	0	40	80	120	160	200	240	280	320
DO (%), at 3 LPM	0	38	55.8	72.4	81.3	84.7	85.5	87.8	88.2
DO (%), at 4 LPM	0	38.9	51.8	72.5	78.3	82.8	84.1	87.9	88.9

Time, s	360	400	440	480	520
DO (%), at 3 LPM	89.7	94.4	91.3	90.4	91.3
DO (%), at 4 LPM	89.9	89.9	90.1	90.1	91.1

4C. **2**

A 5,000 liter (of liquid) bioreactor contains 10 g/L of growing cells, q_{O2} = 40 mmoles O_2 / (g cells hr), D_T = 2 m, D_I = 1 m, (6 – blade turbine agitator) x 3 blades and C_L = 2 mg O_2/L. Calculate OUR.

5A. **4**

Consider a long porous catalyst cylinder, because of a particular arrangement of catalyst within the pores, the concentration gradient of reactant A is $C_A = C_{AS}\frac{r^2}{R^2}$.

What is the total amount of A reacting in any 1-cm length of the cylinder if the radius is 4 cm, the effective diffusivity is 10^{-3} cm^2/s, and the concentration at the external surface (C_{AS}) is 0.002 mol/cm^3.

5B. **4**

Lactic acid is degraded by Lactase enzyme immobilized in a porous sodium-alginate beads. Experiments conducted with different bead sizes result in the following rate data.

i. What are the effectiveness factors for D_p = 3 mm and D_p = 7 mm?

Bead dia, D_p mm	1	2	3	4	5	7	10
Rate, V (mg/L.h)	300	300	250	200	150	100	50

ii. The following data were obtained for D_p = 4 mm at different substrate concentrations. Assuming no liquid film resistance, determine the V_m and K_s for the microbial system.

$[S_o]$, (mg/L)	100	250	500	1000	2000
Rate, V (mg/L.h)	85	200	360	630	1000

5C.	In one region of an unsaturated solution of sucrose, the molar concentration gradient is -0.10 mol/L/cm. What quantity of sucrose molecules pass through an area of 1 cm^2 in 10 minutes? (Diffusion coefficient = 0.522 x 10^{-9} m^2/s)	**2**