Ref. No.: Ex/PG/ChE/T/1210A/2025

M.E. CHEMICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2025

Subject : BIOENERGETICS AND BIOPROCESS ENGINEERING **Time : 3 hr** **Full Marks : 100**

Part I
Assume any missing data
Answer any two questions

1. a.. Derive the expression for non-competitive inhibition. 7

   b. An enzyme has a K_m of 4.10×10^{-5}M. If the V_{max} of the preparation is 22 μmoles lt^{-1} $Mole^{-1}$, what velocity would be observed in the presence of $2x10^{-4}$ M substrate and $5.4x10^{-4}$ of a) a competitive inhibitor, b) a noncompetitive inhibitor c) an uncompetitive inhibitor. K_i in all three cases is 3×10^{-4}M. d) What is the degree of inhibition in all three cases. 18

2. 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=6.7 x 10^{-4} M and V_{max} = 350 nmoles x $lt^{-1}xmin^{-1}$. Galactose – 6 – sulfate is a competitive inhibitor (I). At 10^{-5} M galasctose – 6 – sulfate and 2 x 10^{-5}M glucose-7-sulfate, v was 1.25 nmole x $lt^{-1}xmin^{-1}$. Calculate K_i for galactose – 6- sulfate. 9

   What is the difference between segregated and non-segregated model . Give one example of unstructured segregated model. 6

   Write the application of enzyme in Pulp and paper and Juice industry 3 + 3

   Describe Entrapment immobilization process and its application 4

3. A. Briefly describe secondary metabolites. 3
   B. Briefly describe of semi-solid state fermentation and its application. 4

   C. A strain of mold grown in a batch reactor and glucose is the substrate.

Time (h)	Cell concentration (g/l)	Glucose concentration (g/l)
0	1.25	100
9	2.45	97
16	5.1	90.4
23	10.5	76.9
30	22	48.1
34	33	20.6
36	37.5	9.38
40	41	0.63

   i. Calculate maximum net specific growth rate.
   ii. Calculate apparent growth yield
   iii. What maximum cell concentration can be obtained if 150 gm of glucose was used with same size inoculum 18

[Turn over

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Part-II

Answer any *two* questions

1. (a) What are the advantages and disadvantages of different types of coagulation and flocculation agents used in algae harvesting.
(b) Develop the expression to calculate the settling velocity of an algae biomass particle of spherical shape in a fluid in the laminar flow region (Re<1)
(c) To produce a new algae in a location with low sunlight irradiance, halogen lamps are planned to be installed to irradiate tubular photobioreactors (PBRs) in parallel arrangement with floor area occupied by one PBR=18.6 m^2. The effective continuous irradiance provided by these lamps is 500 μmol m^{-2} s^{-1}. The initial biomass concentration in the feed is 1kg m^{-3}. Calculate:
(i) The algae biomass productivity in a tubular PBR with a volume of 1.7 m^3 for a liquid feed flow rate of 10 m^3h^{-1}.
(ii)The number of PBRs of the given volume capacity and the land used for an oil production of 10000 t y^{-1} assuming an oil content of 35% by mass in the algae biomass. (Assume 300 operating days in a year, μ_{max} =0.1h^{-1}, K1=70 μmol m^{-2} s^{-1}
(iii) If CO_2 is supplied by bubbling 200mol h^{-1} of a flue gas stream containing 10% by mole of CO_2 what will be the CO_2 capture rate in relation to the CO_2 input in the gas stream.

5+5+15

2. (a) Working procedure of microbial fuel cell (MFC) in a single chamber and two chamber set up.
(b) What are the opportunities and challenges in microbe derived industrial production of biofuels?
(c) Briefly describe the pretreatment methods available for lignocellulosic ethanol.
(d) Determine the parameters of the Monod equation for the fermentation of a low cost feedstock into lactic acid using data given below:

Cs (g/L)	100	80	60	55	40	20	10
μ (h^{-1})	0.2671	0.2665	0.2662	0.2653	0.2641	0.2607	0.2509

5+5+5+10

3. (a) Estimate the annual algae biomass production per unit of land for the species X [$P_{c,max}$ =1 d^{-1}, r_m= 0.05 d^{-1}, θ_{max} = 0.09 g chlorophyll g^{-1} C, a= 5 g C (mol^{-1} photons) m^2 g^{-1} chlorophyll]. The steady state concentration is 0.5 kg/m^3 and the pond depth is z = 0.3 m. The actual water surface is 80% of the total area, h = 0.8. Assume algae cultivation at average pond water temperature and sunlight. Neglect the effect of CO_2 and variations in concentration with depth. The monthly average irradiation for the pond location and average pond water temperature is as follows:

Month	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Irradiation (W/m^2)	35	50	80	100	120	150	140	130	100	75	40	35
Water temp (°C)	3	5	8	12	15	20	21	18	16	13	11	3

Calculate the annual oil yield if the avg. oil content in the algae biomass cell is 30%. Given: Top =22°C,Td = 35°C, β = 1.5, oil density = 0.87kg/L
(b) What is algae shadowing effect and how light irradiation is affected by it?

20+5

(c) Briefly discuss:
(a) Algae oil extraction methods
(b) Fast pyrolysis technique for bio-oil production
(c) Solid state fermentation vs submerged fermentation
(d) Pretreatment methods for lignocellulosic ethanol
(e) Working procedure of microbial fuel cell (MFC) in single chamber and two chamber set up.

5*5