Ref. No. Ex/PG/ChE/T/1210A/2024

M.E. CHEMICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2024

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

Part I (50 Marks)

Assume any missing data
Answer any two questions

1. a.. Describe encapsulation immobilization process and its application 5

b. An enzyme has a K_m of 4.2 x 10^{-5}M. If the V_{max} of the preparation is 24 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 non competitive inhibitor c) an uncompetitive inhibitor. K_i in all three cases is 3 x 10^{-4}M. d) What is the degree of inhibition in all three cases. 20

2. A strain of mold was grown in a batch culture on glucose and the following data were obtained:

Time, hr	Cell concentration (g/L)	Glucose concentration, g/L
0	1.25	100
9	2.42	97
14	5	90.4
24	10.5	76.9
30	22	48.1
34	33	20.6
36	37.5	9.38
42	41	0.36

Calculate the maximum net specific growth rate, apparent growth yield and maximum cell concentration could one expect if 120 gm of glucose were used with the same size inoculum. 9

Derive the expression for un-competitive inhibition. 8

Write the application of enzyme in Food and textile industry 4 + 4

3. The following data have been obtained two different initial enzyme concentration for an enzyme-catalyzed reaction.

v ($[E_0]$=0.012 g/l) g/l-min	[S] (g/l)
1.14	20
0.86	10
0.7	6.7
0.59	5
0.5	4
0.45	3.0

i) Find K_m ii) k_2 and iii) find V_m

[Turn over

Where V_m is maximum forward velocity of the reaction, K_m is dissociation constant of the ES (Enzyme – substrate) complex, k_2 is rate constant. 20

What is the difference between structured and unstructured models? What will be the Monod model equation for two limiting substrate 5

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Part-II

Use Separate Answer scripts for each part

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) 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/m3 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	April	May	June	July	Aug	Sept	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: T_{op} =22°C,T_d = 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

3 (a) Working procedure of microbial fuel cell (MFC) in a single chamber and two chamber set up.

5+5+5+10