Ref. No.: Ex/Che/PE/B/T/424D/2025

B.E. CHEMICAL ENGINEERING FOURTH YEAR SECOND SEMESTER EXAM 2025

BIOENERGETICS & BIOPROCESS ENGINEERING

Time: 3 hours **Full Marks: 100**

Answer all questions

<table>
<tr><th>Q. No.</th><th>CO No.</th><th></th><th>Marks</th></tr>
<tr><td>1</td><td>1.</td><td>a)What are the different models for specific growth rate prediction using unstructured non-segregated model?
b)What is the Hanes-Woolf plot?
c)What do you mean by saturation constant in Monod equation for cellular system?
d)What do you mean by electrophoresis of cell?
e)What is an enzyme entrapment?
f)What do you mean by uncompetitive inhibitors?
g)What is an allostery binding?
h) What is a chemostat?
i)What is the Damkohler number?
j)What is a grid counts for determination of cell number density?</td><td>2x10=20</td></tr>
<tr><td>2.</td><td>2.</td><td>a)Derive the rate equation for a homogeneous enzyme-catalyzed reaction using the rapid equilibrium assumption.
b)The following data have been obtained from an enzyme catalyzed reaction using enzyme concentration ($[E_0]$ = 0.00875 g/l).
<table>
<tr><td>Substrate concentration, [s](g/l)</td><td>20</td><td>10</td><td>6.7</td><td>5.0</td><td>4.0</td></tr>
<tr><td>Rate of reaction, γ[g/(l.min)]</td><td>0.67</td><td>0.51</td><td>0.41</td><td>0.31</td><td>0.29</td></tr>
</table>
Estimate using Hanes-Woolf plot: 1) Forward reaction velocity (V_m), 2)Michaelis-Menten constant (K_m), and 3) Rate constant (k_2).</td><td>5+5=10</td></tr>
<tr><td>3.</td><td>3.</td><td>a)Derive Thiele modulus using diffusional effects in enzymes immobilized in a porous matrix.
b)Write the definitions and significances of the Thiele modulus and Effectiveness Factor and plot the graphs of Effectiveness Factor vs Thiele modulus and particle radius.</td><td>10+5=15</td></tr>
<tr><td>4.</td><td>4.</td><td>a)Describe briefly with the help of a neat sketch the various section of cell growth curve.
b)In his (Monod) thesis which was published Monod was proposed equation with his name. As experimental support for this equation from his presented results from 4 batch reactor run on the growth of a pure bacteria culture in a lactose solution. One of his runs produced:
<table>
<tr><td>Time(hr)</td><td>0</td><td>0.54</td><td>0.90</td><td>1.23</td><td>1.58</td><td>1.95</td><td>2.33</td><td>2.70</td></tr>
<tr><td>$C_A(mg.L^{-1})$</td><td>147</td><td>125</td><td>104</td><td>70</td><td>38</td><td>18</td><td>3</td><td>1</td></tr>
<tr><td>$C_C(mg.L^{-1})$</td><td>15.5</td><td>23</td><td>30</td><td>38.8</td><td>48.5</td><td>68.3</td><td>61.3</td><td>62.5</td></tr>
</table>
Fit the Monod equation to this data.</td><td>10+5=15</td></tr>
</table>

[Turn over

5.	5.	a)Briefly write the design and operation of a typical aseptic, aerobic fermentation process. b) Derive the optimum cell concentration using MFR, $C_{C,opt} = Y_{C/A}\,[C_{A0} - \frac{C_{A0}}{1+N}]$, where $N = \sqrt{1 + \frac{C_{A0}}{K_S}}$, and $Y_{C/A}$ = Yield of cell concentration.	5+10=15
6.	6.	a)Describe the mechanical and non-mechanical methods of cell disruption. b) E-coli lives and grows on manitol (Carbon-source) with the following kinetics. $r_c = \frac{1.2\,C_A C_C}{2+C_A}$ g cell. $m^{-3}.h^{-1}$ with Y_{C_c/C_A} = 0.1 g cell/g manitol. Find the outlet concentration of cells produced when 2.5 m^3/h of manitol solution (C_{AO} = 5 g/m^3) is fed directly to a MFR of volume 0.75 m^3. And draw the reactor scheme if the reactor volume is 0.85 m^3.	10+5=15
7.	7.	a)Derive the performance equation of batch reactor in terms of cell formation. b)Derive the performance equation of PFR reactor in terms of cell formation. c)Derive the performance equation of MFR reactor in terms of cell formation. d)Briefly explain the sterilization of the reactors. e)What is the cross-linking of enzyme?	2x5=10