**B.E. CHEMICAL ENGINEERING 4th YEAR 2nd SEMESTER EXAMINATION 2022**
**BIOENERGETICS & BIOPROCESS ENGINEERING**

**Time: 4 hours** **Full Marks: 70**

**Answer all questions**

1. 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 is an enzyme entrapment?
   e) What do you mean by microencapsulation?
   f) What is the cross-linking of enzyme?
   g) What do you mean by uncompetitive inhibitors?
   h) What is an allostery binding?
   i) What is the Damkohler number?
   j) What is a grid count for determination of cell number density? 1x10=10

2. 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:

| Time(hr) | 0 | 0.54 | 0.90 | 1.23 | 1.58 | 1.95 | 2.33 | 2.70 |
|---|---|---|---|---|---|---|---|---|
| $C_A(mg.L^{-1})$ | 147 | 125 | 104 | 70 | 38 | 18 | 3 | 1 |
| $C_C(mg.L^{-1})$ | 15.5 | 23 | 30 | 38.8 | 48.5 | 68.3 | 61.3 | 62.5 |

   Fit the Monod equation to this data. 10+10=20

3. 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).

| Substrate concentration, [s](g/l) | 20 | 10 | 6.7 | 5.0 | 4.0 |
|---|---|---|---|---|---|
| Rate of reaction, y[g/(l.min)] | 0.67 | 0.51 | 0.41 | 0.31 | 0.29 |

   Estimate using Hanes-Woolf plot: 1) Forward reaction velocity ($V_m$), 2) Michaelis-Menten constant ($K_m$), and 3) Rate constant ($k_2$). 5+10=15

4. a) Derive unstructured logistic model equation for batch growth of cells.
   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. $m^{-3}$. $hr^{-1}$ with $Y_{C_c/C_A}$ = 0.1 g cell / g manitol.

   It is required to produce 1 kg cell/day in a batch fermenting. Start with 1 kg/$m^3$ and 0.1 g cell/$m^3$ and continue fermentation until substrate becomes 10 g/$m^3$. The time of filling, empty and cleaning may be taken 0.23 hr. Find the volume of the fermential needed. 5+5=10

5. a) Briefly describe the non-competitive inhibition kinetics.
   b) Explain the different methods of enzyme immobilization?
   c) Explain electrical cell quantification? 5+5+5=15