**M.E. Bioprocess Engineering 1ˢᵗ Year 1st Semester Examination2024**

**Mathematical Modelling of Bioprocesses**

**All symbols have usual significance**

Answer any four questions

Assume any missing data

**Full Marks: 100**

Time 3 Hours

1. a) For an enzymatic reaction correlate the substrate concentration with time for a batch reactor. Corelate the substrate concentration with the residence time of a CSTR. **10**

1. b) For a repeated fed batch reactor develop mathematical model using pseudo steady state assumption to correlate the product concentration with dilution rate and cycle time. **15**

2. a) For a CSTBR with recycle develop all generalized model equations and derive the expression for the steady state concentrations of biomass and substrate. **15**

2b) The dynamicequations for the concentrations of prey, $C_A$ and predator, $C_B$ are as follows:

$$\frac{dC_A}{dt} = \mu_A C_A - \frac{\mu_B C_A C_B}{Y_{B/A}}$$

$$\frac{dC_A}{dt} = \mu_B C_A C_B - k_d C_B$$

Develop the Lotka- Voltera model for the oscillatory prey-predator combination. **10**

3. a) Develop a mathematical model for a batch recombinant culture through differential mass balance of cells with and without plasmid. Correlate $f^+$ with the number of generations. **13**

3. b) What do you mean by effectiveness factor? Develop a mathematical model for a packed bed reactor using enzymes immobilized in solid matrix of spherical shape. **12**

4. a) Develop the summative model for a microbial growth on dual substrate. **10**

4.b) What do you mean by structured modeling of microbial system? Develop the two-compartment structured model for microbial growth. **15**

4. a) Identify the types of interaction in the following cases and develop mathematical model to correlate the differential mass balance of A and B with other parameters of CSTBR. **15**

   i) A grows on S1 produced by B and B grows on S2 produced by A.

**[Turn Over**

ii) A grows on S1 and B grows on S2. Growth of B is inhibited by a compound, I, produced by A.S1and S2 are fed externally.

iii) B grows on a substrate, S2 produced by A. A grows on S1 and is not benefited from B. S1 is fed externally

5.b) What type of model is applicable for substrate inhibited enzymatic reactions? Developing the model, correlate the critical substrate concentration corresponding to maximum reaction rate with $K_M$ and $K_I$. 10

6. a) What do you mean by stability of steady state in a CSTBR? Check the local stability of steady states for a CSTBR at washout condition for dilution rate of D. A microorganism being used follows Monod type growth model and the yield coefficient of the microorganism on the substrate is Y. 11

6 b) Stating all relevant principles of metabolic engineering, develop flux balance equations for the metabolic pathway represented in Figure 1. Develop the coefficient and the rate matrices. State the method how the unknown rates can be determined if some of the rates are known? 14
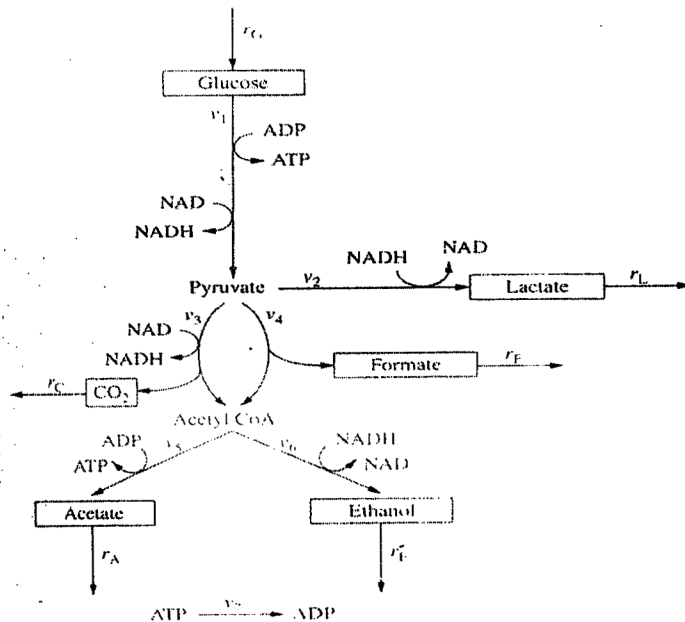


Figure 1