Bioprocess Engineering (BBL331)

Time: 90 minutes **Minor Test** **Total Marks: 30**

1. The growth of a bacterial culture is given by the equation

$$\{1/Xs^{(a+b)}\}(dx/dt) = k(x/Xs)^a [1 - (x/Xs)]^b$$

where 'x' is the biomass concentration at any time 't', 'Xs' is the biomass concentration at stationary phase and 'a' and 'b' are constants. 'k' is the growth rate constant.

a) Calculate the biomass concentration at maximum growth rate
b) Calculate the maximum growth rate

[6]

2. A CSTF of 500 L capacity is operated at steady state while producing a bioproduct by an engineered *E.coli.* The sterile substrate is fed to the reactor at a rate of 15 L/h and the concentration of the substrate in the influent is 10 g/L. The rate of product formation is described as $(\mu\alpha+\beta)X$. Where, α= 0.2 g/g and β= 0.3 g/g-h. Product and biomass yields from substrate are 0.8 g/g and 0.4 g/g, respectively. The Monod kinetic constants are μ_{max} = 0.7 h^{-1} and K_s = 0.2 g/L.

a) Write steady state mass balances for substrate, biomass and product.
b) What are the biomass and substrate concentrations at steady state?
c) What is the productivity of the process?
d) Estimate the influent flowrate which would result in washout of the *E.coli*.

[10]

3. An engineered bacteria is used to obtain a product from glucose. Assume that the growth parameters for this reaction are: K_S = 0.03 mol L^{-1} and μ_{max} X= 13 mol L^{-1} min^{-1}.

a) What should be the size of a steady-state CSTR to convert 95 % of incoming substrate (S_o = 10 mol/L) with a flow rate of 10 L/hr?
b) What do you mean by excess reactant and limiting reactant? Write the expressions to calculate limiting and excess reactants.

[5]

4. In a bioprocess, enzyme is being produced from glucose with the help of an engineered *E.coli* under anaerobic condition. All carbon in the substrate is converted into biomass; ammonia is used as nitrogen source. How does the yield of biomass from substrate in mass and molar terms compare with the maximum possible biomass yield? (consider ash content of the *E.coli* is 5%).

To obtain the same enzyme produced by a different engineered obligate aerobic yeast ($CH_{1.7}O_{0.38}N_{0.21}$), fermenter is operated with methanol and ammonia as carbon and nitrogen sources, respectively. (consider ash content of the yeast is 7%).

a) How does the maximum yield of biomass compare in the two fermentation processes? What is the main reason for the difference?
b) If the actual yield of the yeast from methanol is 40% the thermodynamic maximum, what is the oxygen demand?

[9]