Quiz 6 Name:

Please also put name on back of last sheet for returning assignment

It’s flu season, so TAOCO is interested in developing a biological synthesis for simulating the effect of viruses.

Interleukin 1 (IL-1) is a pyrogenic cytokine that binds to the hypothalamus and causes a rise in body temperature (fever). It is produced from macrophages (white blood cells) via a complex immune response to infection (usually viruses like colds or influenza). TAOCO would like to make IL-1 to simulate the flu in humans (without infecting them with a virus).

TAOCO has engineered a set of multiple recombinant genetically engineered cells to produce IL-1 (product, P) using a yeast extract substrate (S) in a complex fermentation.

Since the reaction is far too complex to easily model from first principles, experiments are run measuring substrate concentration vs. time. You may assume that the drop in substrate corresponds to the formation of IL-1, i.e. reaction is S->P.

1. (5 points) Fit the experimental data with a 6th order polynomial. Provide the coefficients of the fitted polynomial and the correlation coefficient (r).
2. (20 points) As an engineer, you are asked to design a steady state ideal mixed flow reactor (MFR) to conduct this fermentation. Assuming the inlet substrate concentration is 20 gm/L and the outlet substrate concentration is 3 gm/L, with a constant flow rate of 50 L/hr, calculate the volume of the reactor (L).

You must show all work, including your analysis/setup of calculations, for full credit



t, time – hours

C, substrate concentration – gm/L

1. 6th order polynomial fit to data

r=1

1. The mass balance for an MFR is: q\*Cin – q\*Cout +V\*(rate) = 0

q = flowrate, V= volume, rate = rate of reaction

There are 2 unknowns, V and rate. Since you are asked to calculate V, you must determine the rate of reaction.

Note: This equation is equivalent to the space-time parameter () for an ideal steady state MRF,

 = (Cin – Cout)/-rate where  = V/q (See picture below)

The rate is dC/dt. Since you have C(t) from part A, need to determine the value of dC/dt at the outlet concentration.

Setting up an equation to find the time at which the function [named v6(t) below] is equal to 3 gm/L, using a root finding process:

Hence, the time at which the concentration reaches 3 gm/L is 11.012 hours.









Now you need to find the rate at this time.

The rate is the derivative of the concentration vs. time, i.e. dC/dt.

The 6th order model for concentration is:

f(x) = a+ bx+cx2+dx3+ex4+fx5+ex6

so the derivative is: f’(x)=b+2cx+3dx2+4ex3+5fx4+6ex5

Calculating the derivative at t=11.012 gives the rate = -0.644 gm/L-hr.

Plugging this value into the MFR mass balance,

 = (Cin – Cout)/-rate = (20-3)/0.644 = 26.393 hours

V=\*q = 26.393\*50 = 1320 L



Note that this image is the same as the MFR mass balance equation (above), since the space time parameter is simply the area of the rectangle whose width is (Cin-Cout)\*(1/r). Note that the r is the rate at the outlet of the reactor (i.e. at Cout).

 = (Cin – Cout)/-rate

So, if you have a model for C(t) and you know Cout, then you can find the time at which C(t)=Cout. Once you know this time, then you can calculate the rate at the outlet concentration. You can then calculate the space time parameter and hence the reactor volume (given the flowrate).