10.542 – Biochemical Engineering
Spring 2005

Practice Problems for Quiz #2 – Structured Models, Continuous Culture
These problems do not need to be turned in.

1) Consider a structured model that assumes the cell is comprised of four components:

P, the concentration of intracellular precursors
M_1, the concentration of enzymes and RNA involved in cell synthesis
M_2, the concentration of structural macromolecules
G, storage polymers

The total biomass is thus equal to the sum of the four components: $X_T = P + M_1 + M_2 + G$, where all concentrations are in g/L of reactor volume.

Develop expressions for dG/dt, dM_1/dt, dM_2/dt, and dP/dt by assuming the following:

(i) Growth of the cell is limited by the concentration of glucose, S.
(ii) dG/dt is equal to the rate of G formation minus the rate of G degradation. The rate of G formation per unit reactor volume obeys Michaelis-Menten kinetics in the precursor concentration per cell mass and the concentration of M_1 per unit reactor volume. The rate of G degradation is first-order in G.
(iii) dM_2/dt obeys Michaelis-Menten kinetics in the precursor concentration per cell mass and the concentration of M_1 per unit reactor volume.
(iv) dM_1/dt is first order in both M_1 and M_2; the second-order rate constant exhibits Michaelis-Menten dependence on the precursor concentration per cell mass.
(v) dP/dt is proportional to the rate of S uptake per cell mass minus the time derivatives of M_1, M_2, and G.

Use the following notation:
k_1 = g G/g M_1-hr
k_2 = g M_2/g M_1-hr
v_s = g S transported/g XT-hr
γ_i = stoichiometric coefficients
k_{1D} (degradation) = 1/hr
k_3 = g M_1/g M_2-g M_1-hr
K_i = saturation parameters (Michaelis constants)

2) Shuler & Kargi, Problem 6.13

3) Shuler & Kargi, Problem 6.15

4) Shuler & Kargi, Problem 6.18

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