$$\mu_{mA} = 1.0 \text{ h}^{-1}; \quad \mu_{mB} = 0.5 \text{ h}^{-1}$$

$$K_{SA} = K_{SB} = 0.01 \text{ g/l}$$

$$Y_{A/S} = Y_{B/S} = 0.5 \text{ g/g}$$

$$S_0 = 5 \text{ g/l}, \quad a = 10 \text{ cm}^2/\text{cm}^3$$

$$X_{BM}^{At} = 1 \times 10^{-4} \text{ g/cm}^2$$

$$k_{dB} = 0.5\text{h}^{-1}, \quad k_{aB} = 1000 \text{ cm}^3/\text{g-h}$$

16.3. Organism A grows on substrate S and produces product P, which is the only substrate that organism B can utilize. The batch kinetics are

$$\frac{dX_A}{dt} = \frac{\mu_A S X_A}{K_s + S}$$

$$\frac{dX_B}{dt} = \frac{\mu_B P X_B}{K_p + P}$$

$$\frac{dP}{dt} = Y_{P/A} \frac{\mu_A S X_A}{K_S + S} - \frac{\mu_B P X_B}{Y_{X_B/P}(K_P + P)}$$

$$\frac{dS}{dt} = -\frac{\mu_A S X_A}{Y_{X_A/S}(K_S + S)} - \frac{Y_{P/A}}{Y_{P/S}} \frac{\mu_A S X_A}{(K_S + S)}$$

Assume the following parameter values:

$$\mu_A = 0.18 \text{ hr}^{-1}, \quad K_s = 0.42 \text{ g/l}, \quad \mu_B = 0.29 \text{ hr}^{-1}$$
$$K_P = 0.30 \text{ g/l}, \quad Y_{X_A/S} = 0.3 \text{ g/g}, \quad Y_{X_B/P} = 0.5 \text{ g/g}$$
$$Y_{P/S} = 1.0 \text{ g/g}, \quad Y_{P/A} = 4.0 \text{ g/g}, \quad S_0 = 10 \text{ g/l}$$

Determine the behavior of these two organisms in a chemostat. Plot S, P, X_A, and X_B versus dilution rate. Discuss what happens to organism B as the dilution rate approaches the washout dilution rate for organism A. (Courtesy of L. Erickson, from "Collected Coursework Problems in Biochemical Engineering," compiled by H. W. Blanch for 1977 Am. Soc. Eng. Educ. Summer School.)

16.4. The BOD_5 value of a waste-water feed stream to an activated-sludge unit is $S_0 = 300$ mg/l, and the effluent is desired to be $S = 30$ mg/l. The feed flow rate is $F = 2 \times 10^7$ l/day. For the recycle ratio of $\alpha = 0.5$ and a steady-state biomass concentration of $X = 5$ g/l, calculate the following:

a. Required reactor volume (V).
b. Biomass concentration in recycle (X_r).
c. Solids (cells) residence time (θ_c).
d. Hydraulic residence time (θ_H).
e. Determine the daily oxygen requirement.

Use the following kinetic parameters:

$$\mu_m = 1.5 \text{ day}^{-1}, \quad K_s = 400 \text{ mg/l}$$
$$Y_{X/S}^{M} = 0.5 \text{ g dw/g BOD}, \quad k_d = 0.07 \text{ day}^{-1}$$