National Exams May 2016

04-Chem-B4, Biochemical Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a CLOSED BOOK EXAM. Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper. ANSWER ALL FIVE QUESTIONS.

4. Each question is of equal value.

5. Most questions require an answer in short essay format. Clarity and organization of the answer are important.

Question 1 (20 marks)

Immobilized invertase enzyme is utilized in a chemostat (CSTR) at steady state to carry out the inversion of sucrose. The feed sucrose concentration (S_0) is 100 mol/m^3. The enzyme reaction follows Haldane kinetics and the intrinsic enzyme reaction kinetic equation is:

$$v = \frac{v_m}{1 + \frac{K_m}{S} + \frac{S}{K_s}}$$

The reaction rate parameters are v_m = 4.45 x 10^{-3} mol/m^3.s and K_m = 20 mol/m^3 intrinsic reaction rate is maximum at a substrate concentration of 20 mol/m^3. The immobilized enzyme reaction suffers from internal mass transfer (diffusional) limitations. The effective diffusivity of the substrate in the particles was measured to be 3.6 x 10^{-6} cm^2/s. Assume the CSTR (working) volume is 0.001 m^3.

(a) What should the feed flow rate be to get the maximum productivity in the CSTR containing the immobilized enzyme catalyst particles.
(b) What is the Thiele modulus assuming internal mass transfer limitations
(c) Also calculate the effectiveness factor for the immobilized enzyme reaction. Assume the particles are spherical with a radius of 80 mm (quite large beads immobilized on the impeller of the CSTR).

Question 2 (20 marks)

A nutrient medium contains a heat labile vitamin is to be sterilized using HTST (high temperature short time). Assume that the number of bacterial spores originally present in the nutrient medium are 10^9/L. The values of the Arrhenius constant and E_a for the bacterial spores are (k_d = α exp[-E_{0d}/RT]:

E_{0d} = 10 kcal/g-mol

α = 1 x 10^4 min^{-1}

For the inactivation of the heat labile vitamin, the corresponding values of E_{0d} and α are:

E_{0d} = 65 kcal/g-mol

α = 1 x 10^{36} min^{-1}

The initial concentration of the vitamin in the nutrient medium is 30 mg/L. Assume the probability of an unsuccessful fermentation to be 0.0001 (1 microbial spore remaining in 10000 L). Ignore any heat up and cool down periods for the sterilizer. How much of the vitamin will be destroyed in the time taken to sterilize the fermenter to desired values. Assume temperature is constant at 120 deg C.

Question 3 (20 marks)

(i) Compare and contrast aerobic and anaerobic metabolism in living cells (10 marks).

(ii) Discuss and describe in detail **any one** of the following (1); protist kingdom (2) Organelles of eukaryotic cells (10 marks)

Question 4 (20 marks)

Prove from first principles that the overall oxygen mass transfer coefficient in water is approximately the same as the liquid side oxygen mass transfer coefficient.

Question 5 (20 marks)

(i) Explain briefly the principles of fat metabolism in living cells.

(ii) Discuss the process of oxygenic photosynthesis in photoautotrophs.