

Given: Class 13

Due: Class 22

1. Design Components: Determine cell yield, and nutrient and electron acceptor requirements for the following biochemical process reactor. Calculate  $f_c$  and  $f_s$  from thermodynamic data. Ethanol is the carbon source,  $\text{NH}_4^+$  is the nutrient source, and the reactor is an ideal chemostat operated aerobically.

**(Note: it is important to write out each step in detail and clearly so that I can read and understand your work – don't skip steps)**

- A. Calculate values for  $f_c$  and  $f_s$  using half-cell reactions and thermodynamic data.
- B. Calculate the Cell Yield as :
  1. Moles of cells/ mole ethanol
  2. Mass (gm) of cells/ gm of ethanol
- C. Calculate the Nutrient requirement as:
  1. Moles of nitrogen/ mole ethanol
  2. Mass (gm) of nitrogen/ gm ethanol
- D. Calculate the Terminal Electron Acceptor requirement as:
  1. Mole of oxygen/ mole of ethanol
  2. Mass (gm) of oxygen/gm of ethanol
- E. If the flow rate to the chemostat is  $1,000 \text{ m}^3/\text{day}$ , calculate the amount of each of the following in units of: (a) moles/day, (b) kg/day, and (c) lb/day:
  1. Cells produced
  2. Nutrient (N) required
  3. Oxygen required

2. As a biochemical engineer, you are tasked with the assignment of producing ethanol as a substitute gasoline additive for MTBE (methyl tertiarybutyl ether) from glucose in a fermentation process. The goal is to maximize the production of ethanol and minimize the production of cells. Make recommendations to management on the following:

- A. Choice of organism
- B. Choice of Biochemical Pathway
- C. Thermodynamic considerations
- D. What is the function of MTBE as a gasoline additive?
- E. Why is there an interest in an alternative gasoline additive such as ethanol?

3. Production engineers want to make acetate from pyruvic acid in a fermentation process. They propose the following reaction for alcoholic fermentation of glucose using equal initial



- A. Do you approve their plan?
- B. Show calculations that you would use to indicate whether the proposed reaction will work or will not work.
- C. Present your analysis verbally in class if requested.

4. Biomedical Engineering Analysis. Steady-state concentrations of several intermediates of glycolysis in the human erythrocyte have been measured and are presented below. Consider the reaction:  $\text{ATP} \rightarrow \text{ADP} + \text{P}_i$ , where steady-state erythrocyte cell concentrations are 1,850  $\mu\text{M}$ , 138  $\mu\text{M}$ , and 1000  $\mu\text{M}$ , respectively.

- A. Calculate the free energy change ( $\Delta G'$ ) of the reaction
- B. Are the concentrations of ATP, ADP, and  $\text{P}_i$  representative of equilibrium conditions? Explain.
- C. If the standard free energy ( $\Delta G'^\circ$ ) for glycolysis (in the human erythrocyte) is  $-47$  kcal/mol glucose, then calculate the efficiency of energy capture by ATP in the erythrocyte cell.

5. Solve Problem 6.1 (page 200) in the course textbook.

6. Solve Problem 6.13 (page 204-205) in the course textbook.