ABE – 20100 Fall 2016

Homework Set 11
Due Wednesday 12/09 at beginning of class

1. (10 pts) Cell growth in a fermenter produces heat which must be removed to prevent the temperature from rising above the survivable limits of the organism. The fungal species *Penicillium chrysogenum* producing antibiotics in a fermenter generate 27.6 kJ/L per hour. The volume of the well-insulated fermenter is 2 L. The feed temperature is 25°C and the exit temperature is equal to the reactor temperature. *Penicillium chrysogenum* cannot grow above 42°C.

   Assume: Heat capacity of all streams = 4 J/g-°C
   Mass flow rates (in and out) are constant = 1025 g/hr

   a) What is the temperature of the fermenter? Will the cells survive?
   b) At what rate (g/hr) is glucose being consumed to generate this heat? Assume that glucose is consumed aerobically (completely oxidized by O_2 to CO_2 and water (liquid)).

2. (5 pts) ATP hydrolysis shifts the equilibrium of a reaction to favor the products. Suppose that reaction A ↔ B has free energy $\Delta G^{o'}$ = + 20 kJ/mol
   a) Calculate K'_{eq} at 25°C for this reaction.
   b) If ATP is used by an enzyme to catalyze this reaction:
      $A + ATP + H_2O \leftrightarrow B + ADP + P_i + H^+$, calculate K'_{eq} at 25°C for this new reaction

3. (5 pts) Glycolysis can be simplified as:
$Glucose + 2P_i + 2ADP + 2NAD^+ \rightarrow 2\ pyruvate + 2ATP + 2NADH + 2H^+ + 2H_2O$
   a) Calculate the standard, biochemical Gibb's free energy of this reaction.
   b) Assume that the metabolism of glucose to pyruvate does not generate ATP. How much heat is generated?

   Hint: use the following reaction
   $Glucose + 2NAD+ \rightarrow 2\ pyruvate + 2NADH + 2H^+ + 2H_2O$