DEPARTEMENT OF CHEMICAL ENGINEERING

BIOCHEMCIAL ENGINEERING (CBI 310)

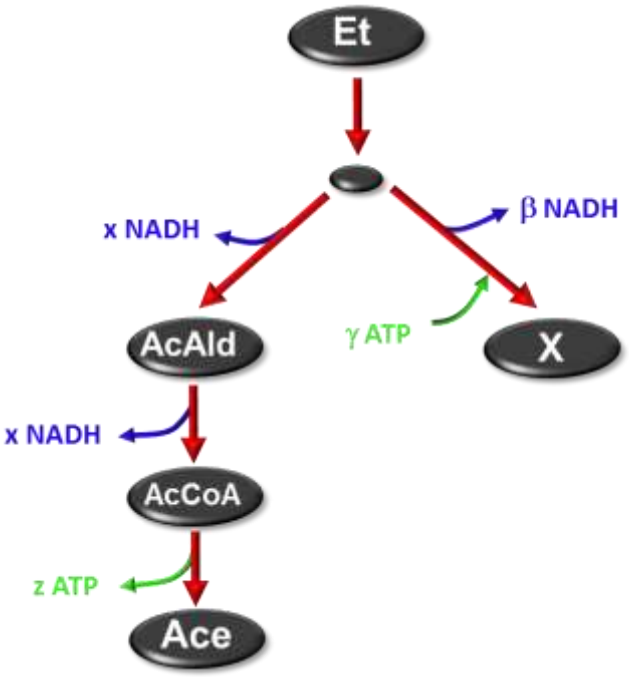
SEMESTER TEST 1

30 MARKS (90 MINUTES)

Read this before you start:

- Any form of communication on your computer will result in serious consequences. There are more ways to monitor this than you are aware of.
- Take care in presenting your scripts, it is the only evidence of your understanding. Neatness is essential
- Remember that Python is only a tool to help you with calculations.

The bacteria genus *Acetobacter* produces acetic acid by using ethanol as substrate. Most commercial vinegar (acetic acid) is produced via the aerobic conversion of ethanol. The metabolic pathway of the process is given by the following:



Note that the left branch of the network (catabolism) represents only two-carbon components (Ethanol (Et), Acetaldehyde (AcAld), Acetyl-CoA (AcCoA) and acetic acid (Ace)). Each mol of AcCoA that reacts to form Ace results in the generation of a mol of ATP. Biomass (X) can be represented by the standard elemental formula ($CH_{1.8}O_{0.5}N_{0.2}$). The value of γ is known to be 2.5 mol ATP/(cmol X).

1) Calculate the degree of reduction of ethanol and acetic acid. [4&6]
2) Consider only the overall reaction from ethanol to acetic acid (neglect biomass formation). Determine via a C,H and O (of C and DOR) balance the amount of NADH produced in the reaction. Express the amount of NADH formed/used per cmol of ethanol consumed. [1 mol/cmol]
3) What is the value of x (see figure) based on a cmol of substrate undergoing transformation? [0.5]
4) Consider only the anabolic reaction (ethanol to biomass). Given that no CO_2 forms in the overall reaction (α=0) and that NH_3 is used as nitrogen source, determine the value of β based per cmol of ethanol consumed. [0.9 mol/cmol]
5) Will the bacteria be able to grow under anaerobic conditions? Give a reason for your answer. [no, NADH build-up]
6) Return to the catabolic reaction only (no biomass formation). Note that the TCA cycle is not operational in the organism, but that oxidative phosphorylation occurs. Given aerobic conditions determine the maximum amount of oxygen that can be consumed in the catabolic pathway. Give answer in mol O_2/(cmol Et consumed in catabolism). [0.5]
7) What is the value of z expressed in mol ATP/(cmol AcCoA consumed)? [0.5]
8) Determine the amount of ATP produced in the catabolic pathway. The $(P/O)_{NADH}$ value is 1.5 for the organism. Give answer in mole ATP/(cmol Et consumed in catabolism). [2]
9) Return to the anabolic reaction only (ethanol to biomass where α=0). Use oxygen to convert any excess of NADH (if present) to water via oxidative phosphorylation . What is the net requirement of ATP in the overall anabolic reaction expressed in mol ATP/(cmol Et consumed)? [1.15]
10) Consider the overall reaction where oxygen is used. Assume that 0.2 gram of biomass forms per gram of ethanol consumed. Determine the mass based acetic acid yield on ethanol. [1.06 g/g]
11) Perform an ATP balance over the anabolic and catabolic half reactions and determine the mass based yield of acetic acid and biomass on ethanol. Note that the biomass specification in (10) does not hold anymore. [Y_{SP}=0.634]