

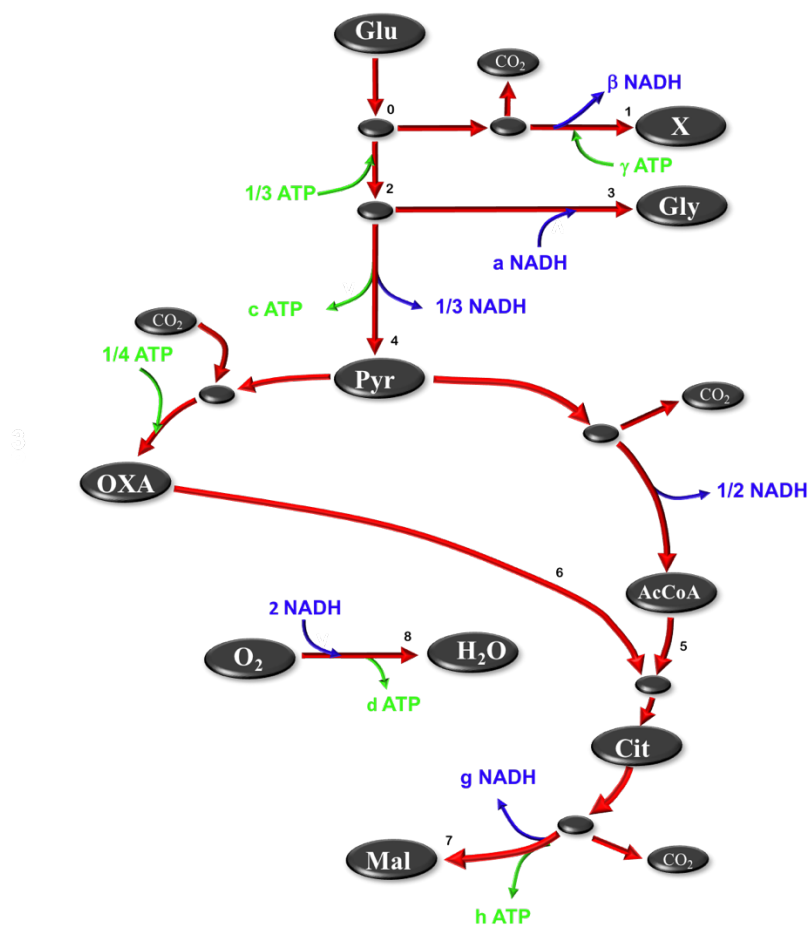


DEPARTEMENT OF CHEMICAL ENGINEERING  
BIOCHEMICAL ENGINEERING (CBI 310)  
SEMESTER TEST 1  
90 MINUTES

Read this before you start:

- Make sure to sit on your allocated seat.
- Any form of communication on your computer/tablet will result in serious consequences. There are more ways to monitor this than you are aware of.
- Use the Click-up template for all answers.
- Log into your computer with: ing\*\*\*.courses. (the \*\*\* refers to the 3 digit number on your computer)

*Aspergillus oryzae* produces glycerol ( $C_3H_8O_3$ ), biomass ( $CH_{1.75}O_{0.45}N_{0.23}$ ) and malic acid ( $C_4H_6O_5$ ) under aerobic conditions. Take the (P/O) ratio for NADH as 1.6 and assume that  $FADH_2 = NADH$ . The metabolism is given by the following cmol based map:





The following is known about the physiology of the microbe:

$\alpha$	$\gamma$	$\mu$	$\theta$
$\frac{cmol CO_2}{cmol X}$	$\frac{mol ATP}{cmol X}$	$\frac{1}{h}$	$\frac{mol ATP}{cmol X \cdot h}$
0.12	2.2	0.15	0.1

1. What is the value of  $a$ ? [1]
2. What is the value of  $\beta$ ? [3]
3. What is the value of  $c$ ? [2]

The cmol balance around the pyruvate node is given as:

$$r_4 = \delta r_6 + \varepsilon r_5$$

4. What is the value of  $\delta$ ? [1]
5. What is the value of  $\varepsilon$ ? [1]
6. What is the value of  $g$ ? [2]
7. What is the value of  $h$ ? [1]
8. Determine  $\kappa$ :  $r_6 + r_5 = \kappa r_7$  [1]

The 'adapted' flux model is given in the attached Excel and Python files (see semester test 1 files under tests). Note that it represents **seven** equations, with the last equation representing the energy balance. All equations are equal to zero except the last equation that is equal to  $\theta$ .

9. Determine the mass based yield of malic acid on glucose in  $g/g$  if the oxygen rate is known to be  $0.13 mol O_2/(cmol X.h)$ . [3]
10. Determine the rate of  $CO_2$  formation for the conditions in question 9. Give answer in  $mol CO_2/(cmol X.h)$ . [2]
11. Determine the rate of water formation/depletion for the conditions in question 9. Give answer in  $mol H_2O/(cmol X.h)$ . [4]
12. Determine the oxygen rate that will result in the formation of zero glycerol. Give your answer in  $mol O_2/(cmol X.h)$ . [3]
13. What is the maximum possible yield of malic acid on glucose. Give your answer in  $g/g$ . [3]
14. For the condition in question 13, how many moles of oxygen ( $O_2$ ) are consumed per **mole** of glucose? [2]
15. Determine  $Y_{xO}$  in  $mol/cmol$  that will result in an **equimolar** formation rate of glycerol and malic acid. Growth occurs at the normal rate. [4]