



DEPARTEMENT OF CHEMICAL ENGINEERING  
BIOCHEMICAL ENGINEERING (CBI 310)  
SEMESTER TEST 2

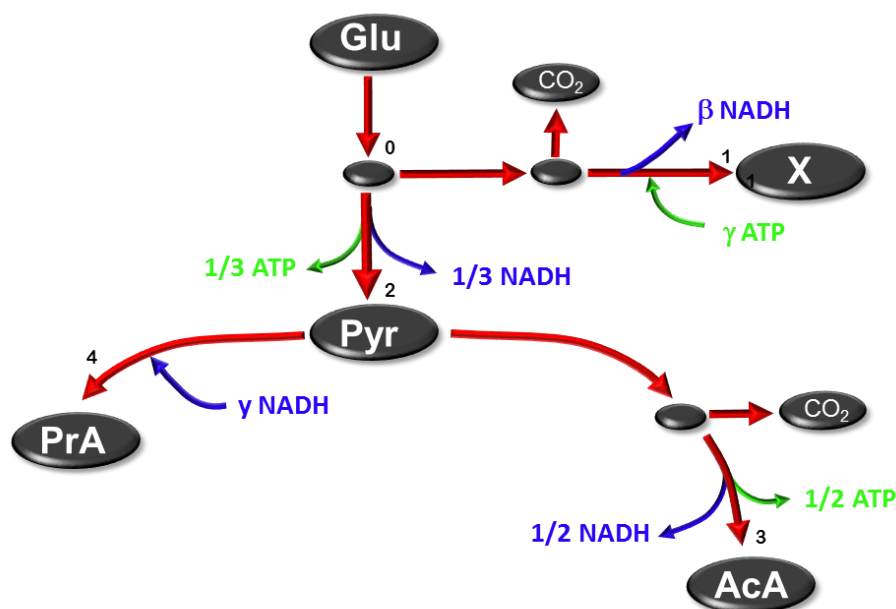
100 minutes

Name:

Student number:

- Any form of communication on your computer will result in serious consequences. Active monitoring is taking place while you are writing.
- Unless a block is provided for hand written input, all questions need to be completed on the Click-up interface.
- Use 3 significant numbers (i.e. 0.303 or 2.31) in the input section.

The anaerobic metabolism of *Propionibacterium acidipropionici* is given below as cmol map.





Only propionic acid (PrA –  $C_3H_6O_2$ ) and acetic acid (AcA) are excreted when glucose is metabolised. The following physiological properties are known:

$\alpha$	0.125	mol $CO_2$ /(cmol X)
$\gamma$	1.8	mol ATP/(cmol X)
$\mu_{max}$	0.22	1/h
$\theta_{max}$	0.09	mol ATP/(cmol X.h)
X	$CH_{1.8}O_{0.5}N_{0.2}$	

1. Determine the value of  $\beta$ . [2]
2. Determine the value of  $\gamma$  by calculating the degree of reduction of pyruvic acid and propionic acid. [3]
3. Note that 4 equations of the flux model were supplied in hidden format (ST2\_model.xlsx) where the fourth row represents the ATP balance (that is equal to  $\theta$ ). This question checks if your own energy balance is correct. Replace row 4 with your own ATP balance and change  $\delta$  to 2.1 mol ATP/(cmol X). All other parameters remain the same while  $\mu$  and  $\theta$  are at the maximum values. **Note that  $\delta$  will be taken as 1.8 mol ATP/(cmol X) for all other questions, so make sure to change it back to the original value after you are done with this question.** What is the rate of propionic acid production in cmol/(cmol X.h)? [3]
4. What is the ratio of propionic acid to acetic acid produced (in cmol/cmol) when only growth (and no maintenance) is considered? [2]
5. What is the ratio of propionic acid to acetic acid produced (in cmol/cmol) when only maintenance (and no growth) is considered? [1]
6. Explain the difference between the answers of questions 4 and 5. You only have the space below so use it wisely! [4]

7. What is the glucose expenditure rate on growth when the total glucose consumption rate is 1 (cmol S)/(cmol X.h). Give answer in (cmol S)/(cmol X.h). [4]



A Batch fermenter run is performed. The initial glucose concentration is 150 g/L while the initial biomass concentration is 0.001 (cmol X)/L. The Monod constant for both growth and maintenance is given by 0.0002 cmol/L. The growth rate is inhibited by propionic acid ( $C_P$ ) according to the following relationship:

$$\mu = \mu_{max}(1 - 0.25C_P^2)$$

8. At what time in the fermentation does growth stop? Your answer need to be within 2% of the correct answer. Give answer in hour. [3]
9. Determine the time when the maximum volumetric growth rate occurs. Your answer need to be within 1% of the correct answer. Give answer in hour. [3]
10. Plot the instantaneous and accumulative yield of propionic acid on glucose (in cmol/cmol) on a single quantitative plot. Accumulative is the overall product yield obtained at the specific instant in time (as if the fermentation is stopped at that instant in time). Note that you only have the space below. [4]

11. Determine the time in the fermentation when the energy expenditure is perfectly balanced between growth and maintenance (1:1). Your answer need to be within 1% of the correct answer. [4]
12. If the value of  $\theta_{max}$  was two times higher, how will the overall product yield (APY) and productivity compare to before (when all glucose is consumed) [4]
  - A) Yield will increase and productivity decrease because more glucose is spent on maintenance.
  - B) Yield will increase and productivity decrease because growth receives less of the ATP available.



- C) Yield and productivity will increase because glucose consumption rates will be higher at all times and instantaneous yields higher during growth.
- D) Yield and productivity will increase because glucose consumption rates will be higher during growth only and instantaneous yields will be higher at all times.
- E) Yield and productivity will increase because glucose consumption rates will be higher during maintenance only and instantaneous yields will be higher under growth conditions only.
- F) Productivity will increase and yield will decrease because growth receives less of the ATP available.
- G) Productivity will increase and yield will decrease because maintenance production is not beneficial for yield.