Charles Darwin University

Final Examination

Family Name						
Given Name/s						
Student Number						
Teaching Period	Semester 1, 2019					

ENG446 – Bioprocess Engineering	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

Please ensure that your name and student number are clearly indicated on your Answer Sheet and at the top of this examination paper.

There are 4 questions in this exam. ANSWER ALL 4 QUESTIONS.

The maximum number of marks is 100.

Each Question carries 25 marks. Marks for sub-questions are indicated.

EXAM CONDITIONS

<u>You may begin writing from the commencement of the examination session.</u> The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

Two A4 sheets of handwritten double-sided notes permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
No additional printed material is permitted	1 x 20 Page Book

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1

In a continuous fermenter with external cell recycle, the limiting substrate concentrations in the feed and in the recycle stream are 12 g/L and 0.15 g/L, respectively. The feed flowrate is set to 15600 L/h. The system is at steady state with the culture volume inside the reactor V = 60000 litres and the biomass yield coefficient is 0.06. The ratio of cell concentration in the cell recycle stream to the cell concentration in the reactor outlet is set at 2. Assume Monod kinetics with $\mu_m = 0.3h^{-1}$ and $K_S = 0.2$ g/L.

a) Calculate the cell concentrations in the reactor outlet stream, the effluent (product stream) and the recycle stream.

(Marks: 15)

b) Calculate the maximum productivity for biomass that can be obtained in this case. What is the percent increase in biomass productivity compared to the case when the system is operated without cell recycle.

(Marks: 10)

Question 2 (Students can use the graph paper in the last page of this exam paper to solve this question)

Gentamycin crystals are filtered through a small test filter. The following data were obtained.

t (sec)	10	20	30	40
V (L)	0.6	0.78	0.95	1.1

The pressure drop in this experiment was 0.2atm, the filter area was $100cm^2$, and the concentration of Gentamycin crystals was 5g/L. The viscosity of the solution was $1.2x10^{-3}$ Pa.s.

a) Calculate the specific filter resistance of the cake, α.

(Marks: 12)

b) For the same pressure drop and crystal concentration, how long would it take to filter 5,000 L of gentamycin solution, using a filter of $1.5m^2$?

(Marks: 13)

Question 3

a) Derive an equation to determine the oxygen transfer rate (OTR) in a fermenter.

(Marks: 10)

b) If oxygen transfer is the rate-limiting step in a fermenter, how could the cell growth rate be increased?

(Marks: 5)

c) ***E.coli***, having a maximum respiration rate (q_{O2max}) of 240mg g^{-1}_{drywt} h^{-1}, is grown in a fermenter of 800L working volume. Volumetric oxygen transfer coefficient (k_La) is 120h^{-1}. Gas containing 80% O_2 is used for the growth, resulting in a saturated oxygen concentration of 28mg/L. The growth is limited by oxygen transfer and the actual respiration rate is given as:

$$q_{O_2} = \frac{q_{O_2 max} C_L}{0.2 + C_L}$$

What is C_L when the cell concentration in the fermenter is 20g/L?

(Marks: 10)

Question 4

a) Explain how the cell and substrate concentrations in a continuous fermenter change with dilution rate (D). What may happen if D is set to a high value?

(Marks: 5)

b) Nutrient medium contaminated with microorganisms is to be thermally sterilised. Sterilisation is carried out at 125^0C. It was found that when the reactor volume increased 100 times, holding time for achieving the same SAL from the same contaminated nutrient medium increased from 50 min to 60 min. Calculate the specific death rate for the sterilisation process. Assume death during heating and cooling steps is negligible.

(Marks: 10)

c) Two species of microorganisms are competing for the same growth-limiting substrate. Explain in detail, and with aid of proper sketches, all possibilities for the outcome of this competition.

(Marks: 10)