Charles Darwin University

Final Examination

Family Name						
Given Name/s						
Student Number						
Teaching Period	Semester 1, 2018					

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.
The examination has 2 sections

Section A: Short Answer Questions. Total No of Marks for this section: 20
This section should be answered in the Answer Booklet provided.
ANSWER ALL 4 QUESTIONS.
Each Question carries 5 marks. Suggested Time allocation for Section A: 40 mins

Section B: Problems Total No of Marks for this section: 80
This section should be answered in the Answer Booklet provided.
ANSWER ALL 4 QUESTIONS.
Each Question carries 20 marks. Marks for each sub-question are indicated.
Suggested Time allocation for Section B: 140 mins

EXAM CONDITIONS

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

This is a RESTRICTED OPEN 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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Section A
Short Answer Questions
Total No of Marks for this section: 20

This section should be answered in the Answer Booklet provided.
ANSWER ALL 4 QUESTIONS.

Each Question Carries 5 marks. Suggested Time allocation for Section A: 40 mins

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Question 1

Write down the reaction mechanism for un-competitive enzyme inhibition.

(Marks: 5)

Question 2

Describe briefly the phenomenon of concentration polarisation that can occur in membrane filtration.

(Marks: 5)

Question 3

List the different ways that volumetric mass transfer coefficient of oxygen in an aerobic bioreactor can be measured.

(Marks: 5)

Question 4

An engineer is in charge of operating a chemostat to produce a chemical using a micro-organism. The product is a primary metabolite of the organism. The marketing department gets a large order for a product which is produced as a secondary metabolite by the organism. The engineer indicates that she can manufacture this product using the same organism and fermenter by adjusting the operating variables. Which is the main operating variable that the engineer will change in order to produce the secondary metabolite? Explain briefly why changing this variable will enable the production of the secondary metabolite.

(Marks: 5)

Section B
Problems
Total No of Marks for this section: 80

This section should be answered in the Answer Booklet provided.
ANSWER ALL 4 QUESTIONS.

Each Question carries 20 marks. Marks for each sub-question are indicated.
Suggested Time allocation for Section B: 140 mins

Question 5

The enzyme urease is immobilised on the surface of a non-porous flat plate. This is placed in an aqueous solution containing urea. The enzymatic reaction at the surface converts urea to ammonia and carbon dioxide. The bulk concentration of urea in the solution is 1000 mg/l. The following parameters are available:

K_M = 200 mg/l; V_M = 0.1 mg urea/cm^2 plate surface / s k_L = 0.2 cm/s;

(a) Calculate the surface concentration of urea.

(Marks: 15)

(b) Calculate the external effectiveness factor.

(Marks: 5)

Question 6

An organism is grown in a chemostat. The feed solution may contain a compound which inhibits cell growth. The specific growth rate is given by:

$$\mu_g = \frac{\mu_m S}{K_{s,app} + S}$$

$$K_{s,app} = K_s \left(1 + \frac{I}{K_I}\right)$$

where I is the concentration of inhibitor in the chemostat. The feed is sterile and the concentration of the growth limiting substrate is 10 g/l. The dilution rate is set to 0.2 h^{-1}. The following parameters are available:

K_s = 1 g/l; K_I = 0.01 g/l; Y_{XS} = 0.1 g cells / (g substrate); μ_m = 0.5 h^{-1}

(a) Calculate the substrate and cell concentration in the chemostat when there is no inhibitor in the feed stream.

(Marks: 8)

(b) Calculate cell productivity when the feed is contaminated with the inhibitor (I = 0.05 g/l).

(Marks: 12)

Question 7

(a) Calculate the maximum concentration of E.coli that can be grown in a bioreactor that has an oxygen mass transfer coefficient capability of 450 h^{-1}.

The following data is available:

Specific respiration rate of E. coli is 0.35 g O_2 (g Cell)$^{-1}$ h^{-1}. Critical oxygen concentration is 0.2 mg/l. Oxygen saturation with air is 6.7 mg/l.

(Marks: 10)

(b) A nutrient medium contaminated with microorganisms is to be thermally sterilised. The initial concentration of living organisms in the medium is estimated to be 1000 spores/l. Sterilisation is carried out at 125^0C. It was found that for a 1 litre bioreactor a SAL of 10^{-6} can be achieved with a holding time of 50 min. Calculate the holding time required to achieve a SAL of 10^{-6} if a 50 litre bioreactor with the same contaminated nutrient medium is used. Assume death during heating and cooling steps is negligible.

(Marks: 10)

Question 8

A wastewater stream at a flowrate of 2 x 10^7 litre/day and a BOD_5 value of 350 mg/l is to be treated using an activated sludge unit to achieve an effluent BOD_5 of 30 mg/l. The recycle ratio is α = 0.5 and the steady state biomass concentration at the exit of the activated sludge reactor is 5 g/l. Assume Monod kinetics.

The following kinetic parameters are available:

μ_m = 1.5 day^{-1}; K_s = 400 mg/l; Y_{XS} = 0.5 gMLVSS/gBOD_5; k_d = 0.07 day^{-1}

Calculate the following:

(a) Solids residence time

(Marks: 5)

(b) Activated sludge reactor volume

(Marks: 7)

(c) Biomass concentration in recycle stream

(Marks: 8)