UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Eng. *M.Eng.*

Biochemical Eng 3008: Biochemical Reaction Engineering

COURSE CODE	:	**BENG3008**
UNIT VALUE	:	**0.50**
DATE	:	**16-MAY-06**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

06-C0109-3-50

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Answer FOUR questions. **Only the first four answers will be marked.**
ALL questions carry a total of 25 each, distributed as shown [ ]

Where numerical integration is required for any question use Simpson's rule as stated below.

For N+1 points where N is even,

$$\int_{X_0}^{X_N} f(X)dX = \frac{h}{3}\left(f_0 + 4f_1 + 2f_2 + 4f_3 + 2f_4 + \ldots + 4f_{N-1} + f_N\right)$$

where $h = \dfrac{X_N - X_0}{N}$

1.

a) The elementary liquid phase reaction A→ B takes place in two continuous stirred reactors connected in series. The concentration of reactant A in the inlet to the first reactor is 1 mol/dm^3, whilst in its outlet is 0.5 mol/dm^3. If the volume of the second reactor is four times that of the first, find the exit concentration from the second reactor. [15]

b) If the order of the reactors is reversed, what is the final exit concentration? [10]

2.

A reaction with the stoichiometry A→ B displays the behaviour indicated below.

C_A (mol/dm^3)	$-r_A$ (mol/dm^{3}min)
1	2
2	5
3	12
4	25
5	40
7	16
8	10
10	6
12	5
20	4

We wish to operate a reactor (or a combination of reactors) in such a way that we get 90% conversion of a feed stream in which the concentration of A is 20 mol/dm^3. If the flowrate is 100 dm^3/min find the reactor working volume:

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a) for a PFR [8]
b) for a CSTR [7]
c) for a combination of one PFR and one CSTR which minimises total reactor volume [10]

3.

This question concerns the application of plug-flow reactors for biocatalytic reactions.

(a) Derive an analytical expression (based on a mass balance) to describe the productivity of an enzyme catalysed reaction in a plug-flow reactor. Assume Michaelis-Menten kinetics apply and state any other assumptions used. [15]

(b) Why is this type of reactor preferable for industrial operation rather than a continuous stirred tank reactor? [5]

(c) For industrial operation why are such reactors frequently used with a recycle? [5]

4.

This question concerns the application of biocatalysis to industrial chemistry.

(a) What are the major uses for biocatalysis currently and in the future? What are the driving forces behind this? [5]

(b) What new technologies will enable the implementation of biocatalysis in the future? [5]

(c) Describe one of these new technologies in detail, using diagrams as required. [15]

5.

This question concerns external diffusional limitations that can occur in an immobilised enzyme for use in a biocatalytic processs.

(a) Define the Damkohler number, Da, which is used to characterise the diffusional limitation at a given substrate concentration. [5]

(b) Explain why the effectiveness factor decreases as the Damkohler number increases. [10]

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(c) Practically how might the Damkohler number be reduced? [5]

(d) List the other factors in a biocatalytic process which lead to a reduction in observed enzyme activity upon immobilisation. [5]

6.

This question concerns biocatalytic reactor kinetics.

(a) Derive the Michaelis-Menten expression (based on a mass balance) to describe the kinetics of a homogeneous single substrate conversion using an isolated enzyme. [5]

(b) Describe the expression derived in (a) graphically with an annotated figure and also with a Lineweaver-Burke plot. [5]

(c) Outline the assumptions necessary for the Michaelis Menten expression to hold. [5]

(d) In industrial processes describe where such an expression breaks down and what modifications to the expression are required to account for this. [10]

END OF PAPER