UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Eng. *M.Eng.*

Chemical Eng E836: Chemical Reaction Engineering

COURSE CODE	:	**CENGE836**
UNIT VALUE	:	**0.50**
DATE	:	**16-MAY-06**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

06-C0219-3-60

TURN OVER

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

Graph paper provided.

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

For N+1 points where N is even,

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

$$\text{where } h = \frac{X_N - X_O}{N}$$

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 0.5mol/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 20mol/dm^3. If the flow rate is 100dm^3/min find the reactor volume:

CONTINUED

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

The elementary liquid phase reaction system

$A \rightarrow B$ (with reaction rate constant $k_1 = 0.001\ s^{-1}$)
$B \rightarrow C$ (with reaction rate constant $k_2 = 0.003\ s^{-1}$)
$B \rightarrow D$ (with reaction rate constant $k_3 = 0.002\ s^{-1}$)

is carried out in a batch reactor in which initially there is pure A.

a) Derive an equation for the concentration of A as a function of time. [4]
b) What is the ratio C_A/C_{Ao} after 1.5 min? [3]
c) Derive an equation for the concentration of B as a function of time. [10]
d) If $C_{Ao}=0.2\ mol/dm^3$, what is the concentration of B after 2 min? [5]
e) At what time is the concentration of B at a maximum? [3]

4

a) What is Knudsen diffusion? [5]

b) Consider a porous catalyst pellet where a reaction occurs and mass/heat transfer resistances exist (both intraphase and interphase). Sketch the radial concentration and temperature profiles for an endothermic and exothermic reaction and explain why the profiles have these forms. [10]

c) Reactant A, which is present in dilute concentrations, is diffusing at steady state from the bulk fluid through a stagnant film of B of thickness δ to the external surface of a spherical nonporous catalyst pellet with diameter d_p. Since $\delta \ll d_p$ we can neglect the curvature of the film. Determine the concentration profile (C_A as a function of film co-ordinate) and the molar flux of A (W_{Az}). [10]

Additional Information
Molecular Diffusivity: $D_{AB} = 10^{-6}\ m^2/s$
Film thickness: $\delta = 10^{-6}\ m$
Total concentration: $C_{T0} = 100\ mol/m^3$
Mole fraction of A at the bulk: $y_{A,bulk} = 0.9$
Mole fraction of A at the surface of the pellet: $y_{A,surface} = 0.2$

PLEASE TURN OVER

5

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]

END OF PAPER