UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualification:-

M.Sc.

D8: Chemical Reaction Engineering

COURSE CODE : **CENG00D8**

DATE : **07-MAY-04**

TIME : **10.00**

TIME ALLOWED : **3 Hours**

04-N0010-3-30

TURN OVER

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,

$$\int_{x_o}^{x_N} f(X)dX = \frac{h}{3}(f_o + 4f_1 + 2f_2 + 4f_3 + 2f_4 + ... + 4f_{N-1} + f_N)$$

where $h = \dfrac{x_N - x_O}{N}$

1.

A liquid phase, elementary, consecutive reaction system

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

takes place isothermally in a batch reactor. The desired product is B. The reaction rate constants are

$k_1 = 7.47 \times 10^{-4}\ s^{-1}$ and $k_2 = 3.36 \times 10^{-4}\ s^{-1}$

a) Calculate the time (t_{max}) required to reach the highest concentration of the intermediate product B. [20]

b) For the situation in (a), what are the corresponding conversion of A, selectivity of B and yield of B? [5]

2.

The liquid-phase, elementary, irreversible reaction A → B is carried out in a system of one CSTR and one PFR connected in series. Pure reactant A enters the first reactor (CSTR) with a volumetric flowrate $4.2 \times 10^{-6}\ m^3\ s^{-1}$ and temperature 20°C. Both reactors operate adiabatically and the conversion of A at the exit of the second reactor (PFR) is 97%. Calculate the volume of the PFR.

Additional data

$\Delta H^o_R = -400\ J\ g^{-1}$
$cp_A = cp_B = 2\ J\ g^{-1}\ K^{-1}$ (independent of temperature)
$k = 7.25 \times 10^{10}\ e^{(-14570/T)}\ s^{-1}$ (T is temperature in K)
$V_{CSTR} = 0.378\ m^3$ [25]

PLEASE TURN OVER

3.

a) A reversible, elementary, liquid phase, exothermic reaction takes place in a CSTR. Explain why for a given reaction rate, there would be an optimal temperature at which to operate the reactor so as to achieve the highest outlet conversion. [6]

b) Show schematically for a reversible, elementary, liquid phase, exothermic reaction, the potential problems of multiplicity that could arise in a CSTR. [6]

c) A liquid phase reaction takes place in an adiabatic CSTR. What would you need to measure to find out if the reaction is exothermic, endothermic or thermally neutral? Explain why. [4]

d) For an irreversible catalytic reaction, increasing temperature increases reaction rate, which is beneficial for the reaction. What does the engineer need to consider in order to determine the highest reactor temperature that can be utilised? [4]

e) Discuss what criteria you would consider in deciding if it is better to run a reaction isothermally or adiabatically. [5]

4.

a) Which noble metals are typically used in automotive catalysts? [3]

b) Discuss at least three issues that one needs to consider when determining the diameter of a multitubular bed reactor. [4]

c) Consider a first order reaction taking place in a CSTR. If the reactant concentration in the feed doubles, what will happen to the reactor conversion? [4]

d) What does the Fisher-Tropsch process produce and from what? [4]

e) In which cases would one use a semibatch reactor instead of a batch reactor? [4]

f) The combination of many CSTRs in series is equivalent to which reactor type? [3]

g) The combination of many PFRs in series is equivalent to which reactor type? [3]

PLEASE TURN OVER

5\.

This question concerns the use of immobilised enzymes within porous particles as biocatalysts for the synthesis of fine chemicals.

a) What is the rationale for enzyme immobilisation? What disadvantages result from immobilisation? [5]

b) Describe in qualitative and quantitative terms what is meant by diffusional limitation in such immobilised biocatalysts. [6]

c) Describe a simple experimental test to establish whether there is internal diffusional limitation in a given system. [4]

d) Using expressions for the Effectiveness Factor, the Damkohler Number and the Thiele Modulus, describe how the diffusional limitations described in (b) can be overcome. [10]

END OF PAPER