UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

M.Sc.

D8: Chemical Reaction Engineering

COURSE CODE	:	**CENG00D8**
DATE	:	**03-MAY-02**
TIME	:	**10.00**
TIME ALLOWED	:	**3 hours**

02-N0018-3-30

TURN OVER

UNIVERSITY OF LONDON

Chemical Engineering

D8

MEng DEGREE; BEng DEGREE

*Answer **FOUR** questions only.*

Each question carries a total of 25 marks distributed as shown [ ].

1. The reversible, elementary, liquid phase reaction A⇔ B takes place in a batch reactor. The reaction rate constants for the forward reaction and the reverse reactions are

A → B $k_1 = \exp(18.42 - 5000/T)\ hr^{-1}$ (where T is in Kelvin)
B → A $k_2 = \exp(36.84 - 10000/T)\ hr^{-1}$

At what temperature should you operate the reactor to get maximum conversion of A when the reaction time is 1 hr ? [20]

What is the reason that this maximum of conversion versus temperature is observed? [5]

(Hint: the temperature is between 260 - 290 K).

2. You have a liquid mixture in a batch reactor which contains 45 mol/dm^3 of A and 5 mol/dm^3 of B. In the mixture of A and B you add a component D which reacts according to the reactions

A+D→ R $-r_A = k_1 C_A C_D$ $k_1 = 21\ dm^3/mol \cdot s$
B+D→ S $-r_B = k_2 C_B C_D$ $k_2 = 147\ dm^3/mol \cdot s$

It is desired that in the final reaction mixture, the ratio of mole fractions of A to B is y_A/y_B=100. If we assume that the reactions proceed until all D is consumed, calculate the initial concentration of D that is required to give the desired final mixture. [25]

3. A dilute aqueous solution of A reacts continuously and isothermally according to the reaction A→ B. The reaction is first order with respect to A with reaction rate constant k = 0.159 min^{-1}. The volumetric flowrate of the feed is $0.5 \cdot 10^{-3}$ m^3/min and the feed concentration of A is 0.15 kmol/m^3. There are two $2.5 \cdot 10^{-3}$ m^3 and one $5 \cdot 10^{-3}$ m^3 reaction vessels available with excellent agitation devices. Calculate the steady state conversion in each of the following cases:

a) The $5 \cdot 10^{-3}$ m^3 vessel is used as a continuous flow reactor. [6]

b) The two $2.5 \cdot 10^{-3}$ m^3 vessels are used as continuous flow reactors in series. [7]

c) The two $2.5 \cdot 10^{-3}$ m^3 vessels are operated as continuous flow reactors in parallel, i.e. half of the feed is sent to each reactor and then the exit streams are joined to form the final product. [6]

d) What is the conversion of an ideal plug flow reactor with volume $5 \cdot 10^{-3}$ m^3? [6]

TURN OVER

4. a) Under what conditions will the inlet and outlet temperatures of an adiabatic continuous flow reactor be similar? [5]

b) What is a "Carberry" reactor? [3]

c) How much is the adiabatic temperature rise for a reaction
$A \rightarrow B$
with
$\Delta H_R = -100$ kJ/mol
$C_p = 100$ J/mol·K
$y_{Ao} = 1$ [6]

d) Give some examples of "green" (i.e. environmentally friendly) solvents. [3]

e) Where is it more likely to find continuous reactors, in the pharmaceuticals or the petrochemicals industry and why? [3]

f) What are the "Levenspiel" plots and how can they be used for reactor design? [5]

5. Outline the logic, using quantitative and qualitative arguments, for selection of a plug-flow packed bed, batch stirred tank, fed-batch stirred tank or continuous stirred tank reactor in the following four cases. The enzyme and reaction properties for these four separate cases are as follows:

a) Reaction requires pH control and high conversion. Enzyme follows Michaelis-Menten kinetics and is costly. [5]

b) Reaction requires pH control and high conversion. Enzyme follows Michaelis-Menten kinetics and is cheap. [5]

c) Reaction requires high conversion. Enzyme exhibits product inhibition and is costly. [5]

d) Reaction requires high conversion. Enzyme exhibits substrate inhibition and is costly. [10]

END OF PAPER