UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualification:-

B.Eng.

Chemical Eng E879: Biochemical Reaction Engineering

COURSE CODE   **: CENGE879**

UNIT VALUE   **: 0.50**

DATE   **: 11–MAY–05**

TIME   **: 10.00**

TIME ALLOWED   **: 3 Hours**

TURN OVER

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

1.
This question concerns the use of immobilised enzymes. Ensure you explain your answers in sufficient depth.

(a) What is the rationale for enzyme immobilisation? [4]

(b) What problems arise when presenting enzymes in this form for potential process implementation and industrial operation? [7]

(c) Describe diffusional limitation in terms of effectiveness factor, Thiele modulus and Damkohler number. [10]

(d) What types of reactors are best suited to operation with an immobilised enzyme? [4]

2.
This question concerns the application of *in-situ* product removal (ISPR) to biocatalytic processes. Ensure you explain your answers in sufficient depth.

(a) Describe the concept of ISPR as applied to biocatalysis. [12]

(b) Under what circumstances is it beneficial to implement ISPR? [4]

(c) What are the constraints on implementation of ISPR on scale-up? [5]

(d) Draw and describe a flowsheet for a typical ISPR-based biocatalytic process using process-medium recycle. [4]

3. This question concerns the kinetics of enzyme-catalysed chemical conversions. Ensure you explain your answers in sufficient depth.

(a) Derive the Michaelis-Menten expression to describe the conversion of a single substrate to product in solution. [15]

(b) What significant feature characterises such kinetics and how does this affect the performance of a continuous stirred tank reactor compared with a continuous plug flow reactor? [5]

(c) Under what circumstances will the expression derived in (a) become invalid? [5]

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4. This question concerns the application of biocatalysis to chemical processing. Ensure you explain your answers in sufficient depth.

(a) Draw a typical flowsheet for an isolated-enzyme based process for chemical synthesis. [5]

(b) In such a process, what are the key capital and operating costs and outline the role of rDNA technology in reducing these costs? [10]

(c) What are the key features of the chemical market served by biocatalysis? [5]

(d) What type of reactions are most commonly mediated by biocatalysis? [5]

5. Hinshelwood and Askey studied the thermal decomposition of dimethyl ether in a batch reactor. For pressures above 0.5 atm the decomposition was first order and proceeded as follows:

$$(CH_3)_2O \rightarrow CH_4 + CO + H_2$$
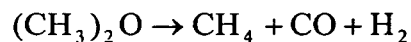
The expression found for the rate constant for the first-order decomposition of dimethyl ether was

$$\ln k = 30.36 - \frac{29440}{T}$$

where k has the units of s^{-1}, T is in K.

It is proposed to carry this same reaction out in a perfectly mixed flow reactor operated at 550°C and 1 atm pressure. Calculate the respective space velocities (evaluated at the temperature and pressure of the reactor) which are required to achieve conversions of 20%, 50% and 80% of pure dimethyl ether in the perfectly mixed flow reactor. Assume that the mixture behaves as an ideal gas. [25]

6. A liquid phase first-order reaction A→B takes place in two reactors of the same volume which are connected in series. There is a constant feed to the first reactor with flowrate 75 m^3/h and reactant concentration C_{Ao} = 1.6 mol/m^3. The reactant concentration at the outlet of the second reactor is 0.1 mol/m^3. The reaction rate constant is k = 0.4 h^{-1}. After several days operation, inlet and outlet flows are stopped. The reaction is allowed to continue for time t_F. At that point (t = t_F), both reactors are emptied into a common container. In order for the product quality to be maintained, the reactant concentration in the mixture of the container must be 0.1 mol/m^3. Find the time t_F. [25]

END OF PAPER