NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF APPLIED CHEMISTRY
END OF SECOND SEMESTER EXAMINATIONS - MAY 2001
REACTOR TECHNOLOGY - SCH 4208
TIME - (3) HOURS

INSTRUCTIONS TO CANDIDATES

Answer **ALL** questions from Section A and **ANY THREE** in Section B. Section A carries 40 marks. Section B 60 marks. Total marks is 100.

SECTION A

1. With reference to gas-solid non-catalytic reactors, discuss:
   (a) The shrinking core reaction model. (6 marks)
   (b) Progressive conversion reaction model. (6 marks)
   (c) Briefly describe a non-elementary reaction. (4 marks)

2 (a) A continuous stirred tank reactor, and a plug flow reactor are two types of reactors. Discuss the advantages and limitations of each type of ractor. (8 marks)

(b) What type of reactor is preferred if the rate of heat of evolution is very high? Give reasons to support your answer. (2 marks)

3 (a) Milk is pasteurised if it is heated to 67°C for 25 minutes, but if it is heated to 78°C it only needs 12 seconds for the same result. Find the activation energy for this sterilization process. (6 marks)

(b) Derive the rate equation for a variable-volume Batch Reactor. (4 marks)

4. With the aid of a sketch diagram draw up the material balance for a steady-state plug flow reactor in terms of conversion (X). (10 marks)

SECTION B

5. The elementary liquid-phase reaction $A + 2B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R$ with rate equation:
$-r_A = -\frac{1}{2}r_B = [12.5 \text{ litre}^2/(\text{mol}^2.\text{min})]C_A C_B^2 - [1.0\text{min}^{-1}]C_R$; $\left[\frac{\text{mol}}{\text{litre.min}}\right]$

is to take place in a 6-liter steady-state mixed flow reactor. Two feed streams, one containing 2.8 mol A/liter and the other containing 1.6 molB/litre, are to be introduced at equal volumetric flow rates into the reactor, and 80% conversion of limiting component B is desired. What should be the flow rate of each stream? Sketch the reactor and fully label the incoming and out going streams, assume a constant density throughout the reactor. (20 marks)

6. Fixed-bed reactors and fluidised-bed reactors are some of the most important industrial reactors. With the aid of sketch diagrams explain their mode of operation and where they are applied. (20 marks)

7. The liquid reaction A + B ------> R + S is to be carried out at in an ideal reactor. Suppose the reaction is carried out in an ideal mixed flow reactor and ideal plug flow reactor such as a mixed flow or a plug flow reactor. The reaction is almost totally irreversible and its rate equation is: $r_A = -kC_AC_B$, where the rate equation constant has the value $0.45 \times 10^{-3}s^{-1}kmol^{-1}m^3$. The initial concentration of A and B are $1.5kmolm^{-3}$ respectively. Calculate the time needed for a turnover of 90% and reactor volume needed for both reactors for a production of 1.5tonnes/day of product. The time needed for cleaning and maintenance is about 1 hour. The molecular weight for R is 120kg/kmol and the density for the solution is $850kgm^{-3}$. Comment on your results. (20 marks)

8 (a) A feed consisting:

25% of 50 -μm - radius particles,
45% of 100-μm - radius particles and
30% of 200-μm - radius particles.

is to be fed continuously in a thin layer onto a moving grate cross-current to a flow reactant gas. For the planned operating conditions the time required for complete conversion is 10, 20, 25 minutes for the three sizes of feed. Find the conversion of the solids in the reactor for a residence time of 15 minutes. (10 marks)

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8 (b) Roasted pyrrhotite (iron sulfide) particles dispersed in asbestos fibres are found that the time for complete conversion was related to particle size as follows:

$T \propto R^{1.5}$

Particles remained as hard solids of unchanging size during reaction. A fluidized-bed reactor is planned to convert pyrrhotite ore to the corresponding oxide. The feed is to be uniform in size, and $\tau = 25$ minutes, with mean residence time, $\bar{t} = 75$ minutes in the reactor. What fraction of original sulfide ore remains unconverted? (10 marks)

END OF QUESTION PAPER!!!!

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