NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF SECOND SEMESTER EXAMINATIONS – APRIL/MAY 1999
REACTOR TECHNOLOGY – SCH 4208
TIME: THREE HOURS

INSTRUCTIONS TO CANDIDATES

There are TWO SECTIONS in this paper. Answer both Sections, with at least *TWO QUESTIONS* from each Section. Answer a total of *FIVE* questions. Graph paper is provided.

SECTION A

1. (a) A continuous stirred tank reactor, a plug flow reactor are two types of reactors in which one can process raw materials. Discuss the advantages and limitations of each type of reactor. (8 marks)

   (b) Compare the operation of a lone CSTR with three stirred tank reactors in series if the volume of each of the three stirred reactors is one third of the lone CSTR. (8 marks)

   (c) What type of reactor is preferred if the initial rate of heat evolution is high? Give an explanation to your answer. (4 marks)

2. (a) What factors must one consider when designing a catalytic reactor? Discuss. (6 marks)

   (b) Compare a fixed bed reactor with a fluidised bed reactor. (4 marks)

   (c) What is a rate limiting step in a heterogenous reaction system? (6 marks)

   (d) Briefly describe *catalytic poisoning*. (4 marks)

3. With reference to gas-solid non-catalytic reactors discuss:

   (a) the shrinking core reaction mode. (6 marks)
   (b) progressive conversion reaction mode. (6 marks)

   (c) Draw sketches of different configurations of plug flow reactors, indicate the reason(s) for choosing any type of PFR you have sketched above. (3 marks)

   (d) Briefly describe main equations to be considered in a mathematical model of a chemical reactor. (5 marks)

4. (a) Describe two advantages and two disadvantages of operating a batch reactor. (8 marks)

(b) Describe two methods which you can use to control the temperature in a batch reactor whose reaction is exothermic. (6 marks)

(c) Determine the time taken to effect a 75% conversion on a first order reaction whose rate constant is $0.00578 min^{-1}$ (6 marks)

SECTION B

5. Determine the fractional conversion of reactant whose flow rate into a $1.5m^3$ continuous stirred tank reactor is $0.125m^3\ min^{-1}$. The initial concentration is 300 mol m^{-3} and the conversion reaction is second order with a rate constant of 180 litre mol^{-1} hr^{-1}. (20 marks)

6. Acetaldehyde is to be decomposed isothermally in a plug flow reactor at 791K and a pressure of 1 atmosphere thus achieving a 50% conversion of the pure feed. The reaction rate constant at this temperature is 0.33 litre mol^{-1} sec^{-1} and the reaction is second order irreversible w.r.t acetaldehyde concentration. Calculate the space time using following information:

At 791K acetaldehyde is a gas:

$$C_o = \frac{P}{RT}$$

$R = 8.314 JK^{-1} mol^{-1}$

$1\ atm = 101\ 325\ Nm^{-2}$

$$\int_o^x \left(\frac{1+x}{1-x}\right)^2 dx = \left[\frac{4}{1-x} - 4Ln\left(\frac{1}{1-x}\right) - (1-x)\right]_o^x$$

$CH_3CHO \longrightarrow CH_4 + CO$

What would be the space time at 90% conversion? (20 marks)

7. A cascade system of three stirred tanks is to be designed to treat a solution containing 0.625 mol l^{-1} of a reactant A. Experiments in the laboratory gave the kinetic data shown below. If the feed rate to system is 9.6 litres per second, what fractional conversion would be obtained if each tank has a volume of 60 litres?.

(20 marks)

REACTION RATE (R) Mol min^{-1}	**REACTANT CONCENTRATION** mol l^{1}
2.0	100
8.0	200
18.0	300
32.0	400
50.0	500
72.0	600
98.0	700
128.0	800

8. Spherical particles of a sulphide ore 2mm in diameter are roasted in an air stream at a steady temperature. Periodically small samples of the ore are removed, crushed and analysed and the following results were obtained.

TIME (HR)	**FRACTIONAL CONVERSION**
0.25	0.333
0.50	0.583
1.0	0.879

Are these results consistent with a shrinking core and chemical reaction rate proportional to the area of the reaction zone? If so ***estimate*** the time for complete reaction of the 2mm particles and the time for complete reaction of similar 600μm particles.

(20 marks)

END OF QUESTION PAPER!!!