UNIVERSITY OF GHANA

BSC ENGINEERING SECOND SEMESTER EXAMINATIONS: 2015/2016

SCHOOL OF ENGINEERING
FPEN 306: CHEMICAL REACTION ENGINEERING (2 CREDITS)

INSTRUCTIONS:
ANSWER SEVEN (7) QUESTIONS – ALL QUESTIONS IN SECTION A AND TWO (2) QUESTIONS IN SECTION B

Graph sheets required

TIME ALLOWED: TWO (2) HOURS

SECTION A

1. Define the following as used in chemical reaction engineering applications

   i. Elementary reaction
   ii. Order of a reaction
   iii. Homogeneous reaction
   iv. Non-elementary reaction
   v. Molecularity of a reaction

2. Describe in detail the dependent factors of the rate equation. For each factor show how it relates to the rate equation.

3. Describe the following ideal reactors noting their distinguishing features:
   i. batch reactor,
   ii. plug flow reactor and
   iii. mixed flow reactor.

4. Consider an irreversible bimolecular second order type reaction taking place in a simple batch reactor. Develop the rate equation for this reaction in terms of conversion and find an expression for the reaction time.

5. Describe the two main methods of analysis of kinetic data giving their advantages and disadvantages.

SECTION B

6. The gas phase decomposition of phosphine with stoichiometry

$$4PH_3(g) = P_4(g) + 6H_2(g)$$

proceeds at 650°C according to a first-order rate equation.

$$-r_{PH_3} = (10/hr)C_{PH_3}$$

The reaction is homogeneous and takes place in a plug flow reactor operating at 650°C and 0.460 MPa and can produce 80% conversion of a feed consisting of 108 mol/hr of pure phosphine. Determine the expansion factor of the reaction and size of the plug flow reactor used. Assume the universal gas constant $\boldsymbol{R}$ = 8.314 Pa.m^3/mol.K

7. An elementary liquid-phase reversible reaction, A + 2B = R; with rate constants k_1 and k_2 for the forward and backward reactions respectively has the following rate equation:

$$-r_A = -\frac{1}{2}r_B = (25\,liter^2/mol^2.min)C_A C_B^2 - (3min^{-1})C_R, \qquad \left[\frac{mol}{liter.min}\right]$$

The reaction take places in a 10-liter steady-state mixed flow reactor. Two feed streams, one containing 2.8 mol A/liter and the other containing 1.6 mol B/liter, are introduced at equal volumetric flow rates into the reactor, and 75% conversion of limiting component is desired. Draw a schematic diagram of the reactor.

i. Determine the performance equation of the reactor.
ii. Determine the flow rate of each stream?

8. Laboratory measurements made prior to the design of chemical reactors for a reaction at 149°C and 10 atmospheres (1013 kPa) provided the following data:

X_A	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.85
$-r_A$ (mol/dm^3.s) x 10^{-3}	5.3	5.2	5.0	4.5	4.0	3.3	2.5	1.8	1.25	1.0

A gas mixture consisting of 50% A and 50% inerts enters the reactor at a flow rate of 10 dm^3/s.

i. Calculate the entering concentration C_{AO} and entering molar flow rate F_{AO}
ii. Calculate the sizes of two continuous stirred tank reactors (CSTRs) connected in series if the intermediate and final products have conversions of 40% and 80% respectively.

Assume the ideal gas constant $\boldsymbol{R}$ = 0.082 dm^3.atm/mol.K

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