UNIVERSITY OF GHANA

BSC ENGINEERING SECOND SEMESTER EXAMINATIONS: 2014/2015

FPEN 306: CHEMICAL REACTION ENGINEERING (2 CREDITS)

INSTRUCTION:

ANSWER ALL QUESTIONS IN SECTION A, AND 3 OTHERS FROM SECTION B (i.e. making a Total of 5 questions)

TIME ALLOWED: 2 HOURS.

SECTION A

1

a) Define and give examples of:

i. Reversible reaction
ii. Irreversible reaction
iii. Equilibrium reaction
iv. Molecularity of a reaction and give examples for uni, bi, and trimolecular reaction
v. Elementary and non-elementary reaction
vi. Order of a reaction
vii. Rate of a reaction
viii. A zero order reaction
ix. Chemical potential
x. Stoichiometry

(20 Marks)

2

A rocket engine burns a stoichiometric mixture of fuel (liquid hydrogen) in oxidant (liquid oxygen). The combustion chamber is cylindrical, 75 cm long and 60 cm in diameter and the combustion process 108 kg/s of exhaust gases. If combustion is complete, find the rate of reaction of hydrogen and of oxygen.

(20 Marks)

SECTION B

3

a) A reaction has the stoichiometric equation A + B = 2R. What is the order of the reaction?

(4 Marks)

b) Given the reaction $2NO_2 + \frac{1}{2}O_2 = N_2O_5$, what is the relation between the rates of formation and disappearance of the three reaction components?

(6 Marks)

c) For the complex reaction with stoichiometry $A + 3B \Rightarrow 2R + S$

and second order rate equation

$-r_A = k1[A][B]$,

are the reaction rates related as follows? If the rates are not so related, then how are they related? Please account for the signs, + or –

(10 Marks)

4

From the following schemes

N_2O_5 ($k_1 \rightleftarrows k_2$) $NO_2 + NO_3$*

NO3 ($\rightarrow k_3$) NO* +O2

NO* + NO_3* ($\rightarrow k_4$) $2NO_2$

a) Show the number of elementary reactions in the schemes shown.

(5 Marks)

b) Show that the reactions identified in Q3a follow a first order decomposition of N_2O_5.

(15 Marks)

5

a) For a gas reaction at 400K the rate is reported as:

$dP_A/dt = 3.66P^2_A$, atm/hr

i. What is the unit of the rate constant?

(8 Marks)

ii. What is the value of the rate constant for this reaction if the rate equation is expressed as

$$-r_A = -\frac{1}{V}\frac{dN_A}{dt} = kC^2, \text{ mol/m}^3\text{.s}$$

(12 Marks)

6

b) A liquid decomposes by first order kinetics, and in a batch reactor 50% of A is converted in 5 minutes run. How much longer would it take to reach 75% conversion?

(12 Marks)

c) A 10 minutes experimental run shows that 75% of liquid reactant is converted to product by a half-order rate. What would be the fraction converted in a half–hour run?

(8 Marks)