THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING

DIPLOMA IN CHEMICAL ENGINEERING

ECH 2307: REACTOR ENGINEERING II

YEAR III SEMESTER II SUPPLEMENTARY EXAMINATION

SERIES: MARCH 2012

TIME: 2 HOURS

INSTRUCTIONS:

You should have the following for this examination:

- *Non-programmable Scientific calculator*
- *Answer booklet*
- *Writing material (Pen, Pencil, Rubber and Ruler) Only!*

This paper consists of TWO sections; **A** and **B**.

Answer **ALL** questions in section **A** and any **TWO** questions in section **B**.

Section **A** carries **30 marks** while section **B** carries **40 marks**.

Each question in section **B** carries **20 marks**.

Maximum marks for each question / part of question are as indicated.

SECTION A

1. (a) Explain what is meant by an elementary reaction. [1 mark]

   (b) Define molecularity and in relation to it, explain why the following reaction is not elementary. [4 marks]

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

2. (a) Define a chain reaction. [1 mark]

   (b) The following mechanism has been proposed for a photochemical reaction of hydrocarbon A.

$$A \rightarrow CH_3 + R$$

$$R \rightarrow D + H$$

$$H + A \rightarrow H_2 + F$$

$$F + F \rightarrow F_2$$

$$F \rightarrow H + M$$

   Identify the initiation, propagation and termination step(s). [4 marks]

3. (a) Explain what is meant by half life of a chemical reaction. [1 marks]

   (b) In the Arrhenius law, the change of the reaction rate constant k, with temperature T, is Given by;

$$\ln \frac{k}{d}$$

   Where; k is reaction rate constant

   T is temperature

   R is universal gas constant

   E_a is activation energy

   Derive an expression of k for a change in temperature from T_1 to T_2. [4 marks]

4. (a) Define the term catalysis. [1 mark]

   (b) Distinguish between homogeneous and heterogeneous catalysis. [2 marks]

   (c) Explain how a catalyst affects the rate of a chemical reaction. [2 marks]

SECTION B

5. Pure gaseous reactant A (C_{A0} = 100 millimol/litre) is fed at steady rate into a mixed reactor (CSTR), (V = 0.1 litre) where it dimerizes (2A → R). For different gas feed rates the following data are obtained:

Run number	1	2	3	4
v_0, litre/hr	30.0	9.0	3.6	1.5
$C_{A,\,out}$, millimol/litre	85.7	66.7	50	33.3

Find a rate equation for this reaction. [20 marks]

6. (a) The rate equation for a chemical reaction; A → products, is always expressed as;
$-r_A = kC_A^n$

(i) Define n and briefly explain how it affects the rate of a chemical reaction. [4 marks]
(ii) With respect to the above expression of the rate equation, state **two** factors that affect the rate of a chemical reaction. [2 marks]

(b) The following data were obtained for the reaction A + B → R + S from investigations carried out in a batch reactor at 298 °K.

$[A]_0$, (mole·L^{-1})	0.100	0.150	0.100
$[B]_0$, (mole·L^{-1})	0.100	0.100	0.200
Rate, (mole·L^{-1}·sec^{-1})	2.73	6.14	2.71

Determine:
(i) the order of the reaction. [12 marks]
(ii) the true rate constant. [2 marks]

7. (a) After 8 minutes in a batch reactor, reactant (C_{A0} = 1 mol/ltr) is 80% converted; after 18 minutes, conversion is 90%. Find a rate equation to represent this reaction. [8 marks]

(b) Consider the following experimental data in the table below obtained from a first order decomposition of organic substance *A*;

A → products

Time (t) in minutes	Concentration of A in mol/dm^3
0.0	0.50
3.0	0.41
6.0	0.34
9.0	0.28
12.0	0.23
15.0	0.19
18.0	0.15

Using the integral method, determine the specific reaction rate constant, k, if the

analysis was carried out in a constant volume batch reactor. [12 marks]