THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

(A CONSTITUENT COLLEGE OF JKUAT)

Faculty of Engineering and Technology

DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING

DIPLOMA IN CHEMICAL ENGINEERING

ECH 2302
REACTOR ENGINEERING I

YEAR III SEMESTER I 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 **20 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 [20 MARKS]

Answer ALL questions in this section.

1. (a) Explain what is meant by an elementary reaction. Use an example. [2 marks]

(b) The reaction between hydrogen and bromine to produce hydrogen bromide;

$$H_2 + Br_2 \rightarrow 2\ HBr$$

proceeds through the elementary reaction steps

$$H\bullet + Br_2 \rightarrow HBr$$

$$Br_2 \leftrightarrow 2Br\bullet$$

$$Br\bullet + H_2 \leftrightarrow HBr + H\bullet$$

Identify the initiation, propagation and termination steps. [3 marks]

(c) Define molecularity and in relation to it, explain why the following reaction is not elementary. [2 marks]

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

2. (a) For a gas reaction at 400 °K the rate is reported as

$$\frac{-d\,p_A}{dt} = 3.66\,p_A^2, atm/hr$$

What are the units of the rate constant? [2 marks]

(b) The rate of a reaction is usually expressed as the change of a reactant or product concentration over time. However, as shown in (a) above, the change in pressure can also be used when dealing with gaseous systems. Explain how concentration and pressure are interchangeably related by deriving the appropriate expression. [3 marks]

3. (a) Explain what is meant by half life of a chemical reaction. [2 marks]

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

$$\ln\left(\frac{k}{d}\right)$$

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. [3 marks]

(c) Give **three** characteristics of catalysts that make them conducive for their purpose. [3 marks]

SECTION B [40 MARKS]

Answer any TWO questions in this section.

4. The table below shows the experimental results of the following reaction;

$A \rightarrow products$

Time, min	0.010	0.005	0.002	0.001
[A], mol/m^3	0.0	0.2	0.4	0.6

Using the graphical method, find the following:

(a) the order of this reaction with respect to A. [18 marks]

(b) the rate constant. [2 marks]

5. (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]

6. (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. [6 marks]

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

$A \rightarrow products$

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. [14 marks]