NATIONAL OPEN UNIVERSITY OF NIGERIA
14-16 AHMADU BELLO WAY, VICTORIA ISLAND LAGOS
MARCH/APRIL 2016 EXAMINATION

SCHOOL OF SCIENCE AND TECHNOLOGY
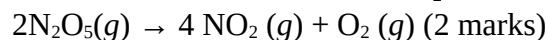
COURSE CODE: CHM407
COURSE TITLE: REACTION KINETICS

**Time:**   **2½hours**
Answer any four questions

Question 1

(a) (i) At 323 K, the rate of reaction for the decomposition of N_2O_5 at a particular instant is2.74 $\times 10^{-4}$ M s^{-1}. Calculate the rate of formation of O_2. The reaction is represented below:

$$2N_2O_5(g) \rightarrow 4 NO_2 (g) + O_2 (g) \text{ (2 marks)}$$

(ii) In the decomposition of hydrogen iodide, what is the relationship between the rate of decomposition of HI and the rate of formation of H_2? (2 marks)

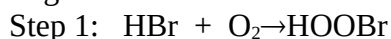(b) An experiment is done to determine the rate of the following reaction:

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 3H_{2(g)} + 2AlCl_{3(aq)}$$
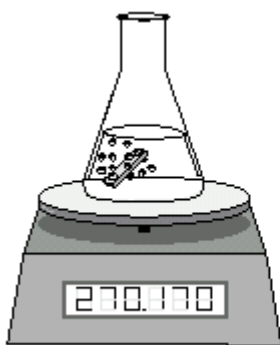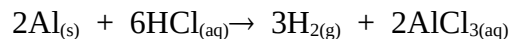
The following data are collected:

TIME (s)	MASS OF FLASK PLUS CONTENTS (g)
0.0	270.230
30.0	270.200
60.0	270.170

(i) Calculate the rate of formation of H_2 in g/sec (2 marks)
(ii) Calculate the rate of formation of H_2 in mol/min. (2 marks)
(iii) Calculate the rate of consumption of Al in g/sec. (2 marks)
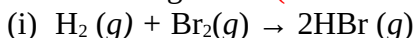
(c) Consider the following mechanism for a reaction:
$$\text{Step 1: } HBr + O_2 \rightarrow HOOBr$$

Step 2:   HBr + HOOBr→ 2HOBr
Step 3: 2HOBr + 2HBr → 2Br$_2$ + 2H$_2$O

Identify the (i) reactant, (ii) product,   (iii) catalyst and   (iv) intermediate in thereaction.
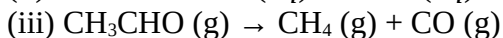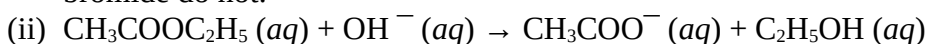(4 marks)

Question 2

(a) Discuss briefly any FOUR experimental methods of rate studies (2 marks each; = 8 marks)

(b) State the name of a suitable experimental method that can be used to monitor the reaction rate in each following cases. (1 marks each; = 3 marks)
  (i) H$_2$ (g) + Br$_2$(g) → 2HBr (g)
      Hint: Bromine absorbs strongly in the visible region, while hydrogen and hydrogen bromide do not.
  (ii) CH$_3$COOC$_2$H$_5$ (aq) + OH$^-$ (aq) → CH$_3$COO$^-$ (aq) + C$_2$H$_5$OH (aq)
  (iii) CH$_3$CHO (g) → CH$_4$ (g) + CO (g)

(c) An elementary reaction, **2 A + C → D**, is second order in A and first order in C. The rate of this reaction is 2.5 x 10^{-1} M/s when the concentrations of A, C, and D are all 1.00 mM. What is the rate constant for the reaction? (3 marks)

Question 3

(a) Consider the following reaction:
           2H$_2$O$_{2(l)}$→ 2H$_2$O$_{(l)}$ + O$_{2(g)}$
Identify the graph that shows the relationship between rate of consumption of H$_2$O$_2$ and time; explain your answer (4 marks).
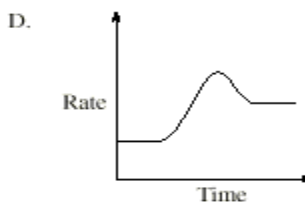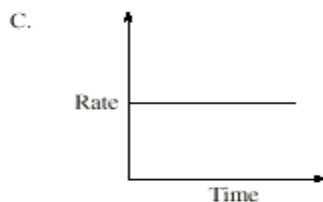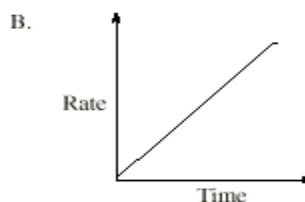
(b) On heating cyclopropane to 770 K, it is converted into propene. In one experiment, the following data were obtained:

T (secs)	0	300	600	900
[Cyclopropane] (M)	1.50 ×10^{-3}	1.24 ×10^{-3}	1.00 ×10^{-3}	8.3 ×10^{-4}

(i) Using graphical method, test whether the above data satisfy first order rate equation. (5 marks)

(ii) Calculate the rate constant (2 marks).

(c) Consider the first order reaction

A → products, which has a rate constant, $k = 2.95 \times 10^{-3}$ s^{-1}. What percent of A remains after 150 s ?(3 marks)
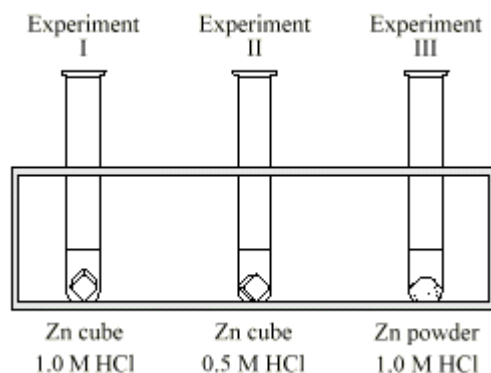
Question 4

(a) Explain how a catalyst affects the rate of a reaction. (2 marks)

(b) The decomposition of hydrogen iodide on gold at 323 K is zeroth order reaction and the rate constant is 1.20×10^{-4} M s^{-1}

  (i) If the initial concentration of hydrogen iodide is 0.500M, calculate its concentration   after 3.00×10^{3} s. (3 marks)

  (ii) How long will it take for all of the hydrogen iodide to decompose? (4 marks)

(c) Consider the following experiments, each involving equal masses of zinc and
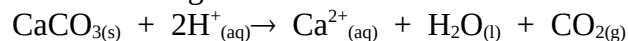   10.0 mL of acid:

Experiment I	Experiment II	Experiment III
Zn cube	Zn cube	Zn powder
1.0 M HCl	0.5 M HCl	1.0 M HCl

Identify the fastest and the slowest reactions. Explain your answer.(5 marks)

Question 5

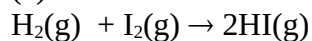(a) What do you understand by the terms: order and molecularity. Distinguish between the two. (4 marks)

(b) (c) Consider the following reaction:
        $CaCO_{3(s)} + 2H^{+}_{(aq)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

(i) List and discuss briefly (using collision theory), **four** factors that would increase the rate of the above reaction. (1 ½ marks each; = 6 marks)

(c) The rate constant for the reaction

$H_2(g) + I_2(g) \rightarrow 2HI(g)$

is 5.4×10^{-4} M^{-1}s^{-1} at 326 °C.   At 410 °C the rate constant was found to be 2.8×10^{-2} M^{-1}s^{-1}.

Calculate
(i)the activation energy (ii) the pre-exponential factor, A (4 marks)

Question 6
(a) What do you understand by the following terms?
   (i) Physisorption (ii) Chemisorption (4 marks)
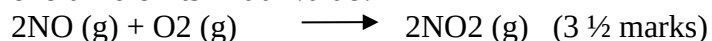(b) List any THREE assumptions of the Langmuir Adsorption Isotherm (3 marks)
(c) List THREE modern methods of surface studies (3 marks)
(d) (i) What is a catalyst? (1 marks)
   (ii) List the three known types of catalysts (3 marks)

QUESTION 7
a)   How will the rate of reaction change if the volume of reaction vessel is diminished to one-third of its initial value?
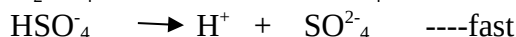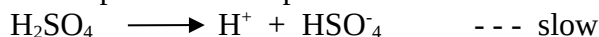$2NO (g) + O_2 (g) \longrightarrow 2NO_2 (g)$ (3 ½ marks)
b)   Assuming a reaction of the form, $Aa + Bb \longrightarrow$ products, and if the rate law for this reaction is given as,
Rate $= K[A]^{1/2} [B]^2$ (3 ½ marks)
Find the order of the reaction and the unit of the rate constant.
c) The half-life t ½ of a chemical reaction is 2234 seconds. Find the first order constant for the reaction.   (3 ½ marks)
d) The decomposition of sulphuric acid occurs according to the following mechanism:
     $H_2SO_4 \longrightarrow H^+ + HSO^-_4$ - - - slow
     $HSO^-_4 \longrightarrow H^+ + SO^{2-}_4$ ----fast
The experimentally determined rate law is given as Rate $= K [H_2SO_4]$ since $[H_2SO_4] = 1$. Is this an acceptable mechanism?   (3 ½ marks)