



TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
UNIVERSITY EXAMINATION FOR THE BACHELOR OF
TECHNOLOGY IN APPLIED CHEMISTRY
(BTAC 14S & BTAC 15S2)
ACH 4201 : CHEMICAL KINETICS AND REACTION DYNAMICS
END OF SEMESTER EXAMINATION

SERIES: APRIL 2016

TIME: 2 HOURS

DATE: Pick Date Apr 2016

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attempt question ONE (Compulsory) and any other TWO questions.

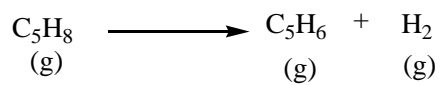
Do not write on the question paper.

QUESTION ONE

- a) Differentiate between each of the following:
- i. Rate and rate law of a reaction (3 marks)
 - ii. Average and instantaneous rate (3 marks)
- b) Consider the reaction
- $$\begin{array}{ccccccc} 4\text{NO}_2 & + & \text{O}_2 & \longrightarrow & 2\text{N}_2\text{O}_5 \\ (\text{g}) & & (\text{g}) & & (\text{g}) \end{array}$$

Suppose that, at a particular moment during the reaction, molecular oxygen is reacting at the rate of 0.024M/s. At what rate is:

- i. N_2O_5 being formed? (2 marks)
- ii. NO_2 reacting? (2 marks)
- c) The decomposition of a certain insecticide in water follows first-order kinetics with a rate constant of 1.45yr^{-1} at 12°C . A quantity of this insecticide is washed into a lake on 1st June, leading to a concentration of $5.0 \times 10^{-7}\text{g/cm}^3$. Assume that the average temperature of the lake is 12°C .
- i. What is the concentration of the insecticide on 1st June of the following year? (3 marks)
- ii. How long will it take for the concentration of the insecticide to drop to $3.0 \times 10^{-7}\text{g/cm}^3$? (3 marks)
- d) The following data were obtained for the decomposition of cyclopentene at 825K .



Time(s)	$[\text{C}_5\text{H}_8]$ (mol/L)
0	0.0200
20	0.0189
50	0.0173
100	0.0149
200	0.0112
300	0.0084
400	0.0063
500	0.0047
700	0.0027
1000	0.0011

Using the data above at this temperature, determine the

- i. Order of reaction (9 marks)
- ii. Rate constant (2 marks)
- iii. Half-life of reaction (3 marks)

QUESTION TWO

- a) The Michaelis-Menten enzyme kinetics equation is given as:

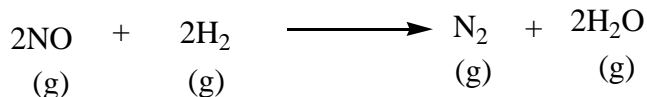
$$V_o = \frac{V_{\max} [S]}{K_m + [S]}$$

- i. Define all the variables in the above equation (2 marks)
- ii. State the main assumptions used to derive this equation (6 marks)
- b) Briefly highlight the main features of the collision theory of chemical kinetics (8 marks)

- c) Discuss how each of the following affects the rate of enzymatic reaction.
- Substrate concentration (2 marks)
 - Non-competitive inhibitors (2 marks)

QUESTION THREE

- a) Briefly discuss how the collision theory explains the influence of temperature on the rate of reaction. (6 marks)
- b) The reaction of nitric oxide with hydrogen at 1280°C is:

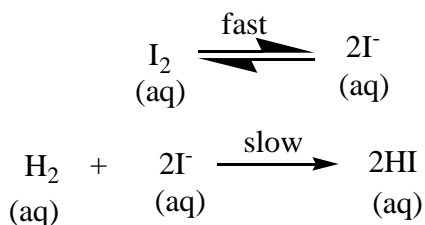


The following data is collected at this temperature:

EXPERIMENT	[NO] (M)	[H ₂] (M)	Initial Rate (M/s)
1	5.0 x 10 ⁻³	2.0 x 10 ⁻³	1.3 x 10 ⁻⁵
2	10.0 x 10 ⁻³	2.0 x 10 ⁻³	5.0 x 10 ⁻⁵
3	10.0 x 10 ⁻³	4.0 x 10 ⁻³	10.0 x 10 ⁻⁵

Determine the:

- Rate law (4 marks)
 - Rate constant (1.5 marks)
 - Rate of reaction when [NO] = 12.0 x 10⁻³M and [H₂] = 6.0 x 10⁻³M (1.5 marks)
- c) Consider the reaction mechanism



Derive the rate law if the reaction is dependent on the concentration of both H₂ and I₂ (4 marks)

- d) From the rate law in (i) determine the:
- Order of reaction with respect to each reactant (1 marks)
 - Overall reaction order (1 marks)
 - Molecularity of reaction (1 marks)

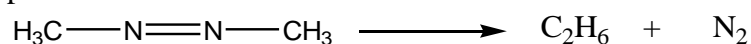
QUESTION FOUR

- a) The growth of *pseudomonas* bacteria is modeled as a first-order process with $k = 0.023 \text{ min}^{-1}$ at 37°C. The initial *pseudomonas* bacteria population density is $1.0 \times 10^3 \text{ cells/L}$.

- i. What is the population density after 3 hours 20 minutes? (4 marks)
- ii. What is the time required for the population density to increase from 1.0×10^3 to 2.0×10^3 cells/L? (4 marks)
- b) Differentiate between:
- i. Reaction mechanism and rate-determining step (3 marks)
- ii. Elementary and complex reaction (3 marks)
- c) Sketch a potential energy profile for a three-step endothermic reaction in which the second-step is rate-determining. (6 marks)

QUESTION FIVE

- a) Discuss the key features of the transition state theory applied to bimolecular reactions. (8 marks)
- b) The rate of decomposition of azomethane ($C_2H_6N_2$) is studied by monitoring the partial pressure of the reactant as a function of time:



The following data was obtained at $300^\circ C$.

Time (s)	Partial pressure of azomethane (mmHg)
0	284
100	220
150	193
200	170
250	150
300	132

From the above data at the given temperature determine:

- i. The rate constant (10 marks)
- ii. Half-life of the reaction (2 marks)