



MACHAKOS UNIVERSITY

University Examinations 2019/2020 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL EDUCATION)

BACHELOR OF EDUCATION (SCIENCE)

SCH 305: CHEMICAL KINETICS

DATE: 3/12/2019

TIME: 11.00-1.00 PM

INSTRUCTIONS TO CANDIDATES

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Required data

- Gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ($0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$)
- $0^\circ\text{C} = 273.15 \text{ K}$

Section A - Compulsory.

QUESTION ONE (30 MARKS)

a) Define the following terms as used in chemical kinetics:

- i. Molecularity of a reaction (1 mark)
- ii. Rate law of a reaction (1 mark)
- iii. Activation energy (1 mark)
- iv. Elementary reactions (1 mark)
- v. Order of a reaction (1 mark)

b) Consider the general reaction; $A + 2B \rightarrow 2C$. From the following data obtained at a certain temperature,

Exp.	[A] (M)	[B] (M)	Initial Rate (M/s)
1	0.30	0.30	0.10
2	0.30	0.60	0.40
3	0.60	0.30	0.20

Determine the:

- i. Rate law for the reaction (4 marks)
- ii. Overall order of the reaction (1 mark)
- iii. Rate constant (2 marks)

c) Given the data below;

T (K)	625	635	645
K (s^{-1})	1.1×10^{-4}	1.5×10^{-4}	2.0×10^{-4}

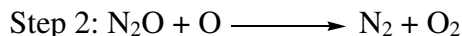
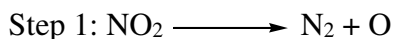
- i) Determine the activation energy of the reaction. (4 marks)
 - ii) Calculate the rate constant for the reaction at 327 °C. (2 marks)
- d) A certain compound (A) decomposes at a certain temperature in the gas phase as follows:

$A_{(g)} \rightarrow B_{(g)} + C_{(g)}$. The following data was obtained.

Time (min)	0	15	30	48	75
[A] (M)	0.36	0.30	0.25	0.19	0.13

- i) Determine if the above data support a first order reaction. (5 marks)
- ii) Calculate the rate constant for the reaction. (2 marks)

- e) The gas-phase decomposition of nitrous oxide (N_2O) is believed to occur in two steps:



Experimentally the rate law was found to be $\text{rate} = k[\text{N}_2\text{O}]$

- Write the equation for the overall reaction (3 marks)
- Identify the intermediates (1 mark)
- Identify the rate-determining step. Justify your answer (1 mark)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

- a) i) For an enzyme-catalysed reaction, show that $v = \frac{v_{\max}[\text{S}]}{K_M + [\text{S}]}$ where v is the rate of reaction, $[\text{S}]$ is the substrate concentration and K_M is the Michaelis constant (8 marks)
- ii) Explain the significance of Michaelis constant (K_M) (2 marks)
- b) The initial rates (v_0) at various substrate concentrations for an enzyme-catalysed reaction are as follows:

$[\text{S}] / \text{M}$	2.5×10^{-5}	4×10^{-5}	6×10^{-5}	8×10^{-5}	16×10^{-5}	20×10^{-5}
$v_0 \times 10^{-6} \text{ M min}^{-1}$	38.0	53.4	68.6	80.0	106.8	114.0

- Show that this reaction follow the Michaelis-Menten kinetics (5 marks)
- Determine the $v_{\max}$ of the reaction (1 mark)
- Calculate the K_M value of the reaction (2 marks)
- Calculate the initial rates at $[\text{S}] = 5.0 \times 10^{-5} \text{ M}$ (2 marks)

QUESTION THREE (20 MARKS)

- Define a chain reaction (1 mark)
 - Explain using the photochemical reaction between hydrogen and bromine, the essential features of a chain reaction (8 marks)
- Explain the use of the differential method in determination of the order of a chemical reaction (6 marks)
- Explain the steady state approximation concept (5 marks)

QUESTION FOUR (20 MARKS)

- a) The kinetic equation for a reaction of order n in substance A is written as:

$$-\frac{d[A]}{dt} = k[A]^n. \text{ Show that the half-life, } t_{1/2}, \text{ is: } \ln t_{1/2} = \ln \left(\frac{2^{n-1} - 1}{k(n-1)} \right) - (n-1) \ln A_0$$

- b) such that A_0 is the initial molar concentration of substance A. (8 marks)
- c) Explain three factors that affect the explosion limits in branched chain reactions (6 marks)
- d) Derive the kinetic equation of a second order reaction, in a single substance and show that the half-life ($t_{1/2}$) as a function of the initial reactant concentration (6 marks)

QUESTION FIVE (20 MARKS)

- a) Explain the meaning of the following:
- i. Simultaneous reactions (1 mark)
 - ii. Complex reactions (1 mark)
 - iii. Consecutive reaction (1 mark)
 - iv. Parallel reactions (1 mark)
 - v. Unimolecular reactions (1 mark)
 - vi. Activation energy (1 mark)
- b) i Define half-life ($t_{1/2}$) of a reaction (1 mark)
- ii Show that for a first order rate reaction, the half life ($t_{1/2}$) is independent of initial concentration. (4 marks)
- c) Show that for a first order reaction kinetics; $[A] = [A]_0 e^{-kt}$ (3 marks)
- d) Explain **three** factors that affect the rate of a chemical reaction (6 marks)