MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD SUPPLEMENTARY/SPECIAL EXAMINATION FOR BACHELOR OF EDUCATION (SPECIAL SCIENCE) AND BACHELOR OF EDUCATION (SCIENCE)

SCH 305: CHEMICAL KINETICS

DATE: 14/03/2022 **TIME: 11:00-1:00 PM**

INSTRUCTIONS:

- 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 J K^{-1} mol^{-1} (0.08206 L atm K^{-1} mol^{-1})
- 0 ºC = 273.15 K

Section A - Compulsory

1. 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 ºC. (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:

Step 1: $NO_2 \longrightarrow N_2 + O$

Step 2: $N_2O + O \longrightarrow N_2 + O_2$

Experimentally the rate law was found to be rate = $k[N_2O]$

i) Write the equation for the overall reaction (3 marks)

ii) Identify the intermediates (1 mark)

iii) Identify the rate-determining step. Justify your answer (1 mark)

Section B

Answer any two questions

2. a) i) For an ezyme-catalysed reaction, show that $v = \frac{v_{max}[S]}{K_M + [S]}$ where v is the rate of reaction, [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 ezyme-catalysed reaction are as follows:

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

i) Show that this reaction follow the Michaelis-Menten kinetics (5 marks)

ii) Determine the v_{max} of the reaction (1 marks)

iii) Calculate the K_M value of the reaction (2 marks)

iv) Calculate the initial rates at [S] = 5.0×10^{-5} M (2 marks)

3. a) i) Define a chain reaction (1 mark)

ii) Explain using the photochemical reaction between hydrogen and bromine, the essential features of a chain reaction (8 marks)

b) Explain the use of the differential method in determination of the order of a chemical reaction (6 marks)

c) Explain the steady state approximation concept (5 marks)

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

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

such that A_0 is the initial molar concentration of substance A. (8 marks)

b) Explain three factors that affect the explosion limits in branched chain reactions (6 marks)

c) 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)

5. 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; $[A] = [A]_0e^{-kt}$ (3 marks)

d) Explain **three** factors that affect the rate of a chemical reaction (6 marks)