MACHAKOS UNIVERSITY

UNIVERSITY EXAMINATIONS 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER SPECIAL/SUPPLEMENTARY EXAMINATION

FOR

BACHELOR OF EDUCATION (SPECIAL SCIENCE) AND

BACHELOR OF EDUCATION (SCIENCE)

SCH 305: CHEMICAL KINETICS

DATE: 24/9/2019 **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, $R = 8.314\ J\ K^{-1}\ mol^{-1}$ ($0.08206\ L\ atm\ K^{-1}\ mol^{-1}$)
- $0\ ^{\circ}C = 273.15\ K$

Section A - Compulsory.

1. a) Given the data below;

T (K)	300	310	320
K (s^{-1})	3.9×10^{-2}	1.1×10^{-1}	2.8×10^{-1}

i) Determine the activation energy of the reaction. (4 marks)

ii) Calculate the rate constant for the reaction at 80 ºC. (2 marks)

b) For the reaction A + B → C + D, the experimental rate law is Rate = $k[B]^2$. Determine;

i) The order of the reaction with respect to A and B (2 marks)

ii) The overall order of the reaction (1 mark)

iii) The plausible mechanism for the reaction (2 marks)

c) The reaction between NO_2 and CO to produce NO and CO_2 is believed to occur in two steps:

$$\text{Step 1: } NO_2 + NO_2 \longrightarrow NO + NO_3$$

$$\text{Step 2: } NO_3 + CO \longrightarrow NO_2 + CO_2$$

Experimentally the rate law was found to be rate = $k[NO_2]^2$

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

ii) Identify the intermediates (2 marks)

iii) Identify the rate-determining step. Justify your answer (2 marks)

d) i) For an ezyme-catalysed reaction, show that $K_M = \frac{\nu_{max}[S]}{\nu} - [S]$ where K_M is the Michaelis constant, v is the rate of reaction and [S] is the substrate concentration.

(10 marks)

ii) Explain the significance of Michaelis constant (K_M) (2 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

2. a) Explain **three** factors that affect the reaction rate of a chemical reaction (3 marks)

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

(5 marks)

c) The variation of the rate constant with temperature for a first-order kinetics;

$2N_2O_{5(g)} \rightarrow 2N_2O_{4(g)} + O_{2(g)}$ is given in the table below;

T (K)	298	308	318	328	338
k (s^{-1})	1.74×10^{-5}	6.61×10^{-5}	2.51×10^{-4}	7.59×10^{-4}	2.40×10^{-3}

Determine graphically, the value of the activation energy of the reaction (5 marks)

d) The data below was obtained at 300 ºC;

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

i) Determine if the above data support a first order reaction. (5 marks)

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

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

i) Order of a reaction (1 mark)

ii) Molecularity of a reaction (1 mark)

iii) Rate constant (1 mark)

iv) Activation energy (1 mark)

b) Consider the general reaction; A + B → Products. From the following data obtained at a certain temperature,

Exp.	[A] (M)	[B] (M)	Initial Rate (M/s)
1	1.50	1.50	3.20×10^{-1}
2	1.50	2.50	3.20×10^{-1}
3	3.00	1.50	6.40×10^{-1}

Determine the:

i) Rate law for the reaction (3 marks)

ii) Overall order of the reaction (1 mark)

iii) Rate constant (2 marks)

c) 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 $[S] = 5.0 \times 10^{-5}$ M (2 marks)

4. a) i) Explain the effect of a catalyst on the rate of a chemical reaction (3 marks)

ii) Highlight two advantages of homogeneous catalysis over heterogeneous catalysis (2 marks)

b) i) Define a chain reaction (1 mark)

ii) Explain using the photochemical reaction between hydrogen and chlorine, the essential features of a chain reaction (4 marks)

c) Explain the steady state approximation concept (4 marks)

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

5. a) i) Define half-life ($t_{1/2}$) of a reaction (1 mark)

ii) Show that the half life ($t_{1/2}$) of a first order reaction is given by $t_{1/2} = \frac{\ln 2}{k}$ (5 marks)

iii) Derive the half-life ($t_{1/2}$) of an n^{th} order reaction of a substance A. (5 marks)

b) 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)

c) In a particular reaction, the time required to complete half of the reaction was found to increase three times when the initial concentration of the reactant was reduced to one third. Determine the order of the reaction (3 marks)