MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF EDUCATION (SPECIAL EDUCATION)

BACHELOR OF EDUCATION (SCIENCE)

SCH 305: CHEMICAL KINETICS

DATE: 16/8/2021 **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.

QUESTION ONE (30 MARKS)

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

i. Complex reactions (1 mark)

ii. Molecularity of a reaction (1 mark)

iii. Half-life of a reaction (1 mark)

iv. Steady state approximation (1 mark)

v. Rate determining step of a reaction (1 mark)

b) Nitric oxide combines with hydrogen as follows; $2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(l)}$. From the following experimental data;

Experiment	[NO] (M)	[H_2] (M)	Initial Rate (M/s)
1	0.420	0.122	0.1360
2	0.210	0.122	0.0339
3	0.210	0.244	0.0678
4	0.105	0.488	0.0339

Determine the:

i. Rate law for the reaction (4 marks)

ii. Overall order of the reaction (1 mark)

iii. Rate constant (2 marks)

iv. Rate of reaction when [NO] = 0.550 M and [H_2] = 0.199 M (2 marks)

c) Using the data below obtained from a certain reaction;

T (°C)	189.7	198.9	230.3	251.2
K (s^{-1})	2.52×10^{-5}	5.25×10^{-5}	6.30×10^{-4}	3.16×10^{-3}

Determine the:

i. Activation energy of the reaction (4 marks)

ii. Rate constant for the reaction at 540 K (2 marks)

iii. Arrhenius factor, *A* (2 marks)

d) The rate law for the reaction; $2NO_{2(g)} + F_{2(g)} \rightarrow 2NO_2F_{(g)}$ was experimentally found to be; Rate = k[NO_2][F_2]. Determine the;

i. Plausible mechanism for the reaction (3 marks)

ii. Rate-determining step for the reaction (1 mark)

e) Given the following information;

Concentration (M)	1.00	0.50	0.33
Time (s)	10	20	30

i. Proof that the above data support a second order reaction (3 marks)

ii. Determine the value of the rate constant, k for the reaction (1 mark)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) Explain the effect of a catalyst on the rate of a chemical reaction. (2 marks)

b) In enzyme-catalyzed reactions, the kinetic parameters are determined by the Michaelis–Menten equation. Show that $v=\frac{v_{max}[S]}{K_M+[S]}$ where v is the initial rate of reaction, [S] is the substrate concentration and K_M is the Michaelis constant (8 marks)

c) The initial reaction rates (v_o) at various substrate concentrations for an enzyme-catalyzed reaction are as follows:

[S]/10^{-4} M	2.1	4.2	9.3	14.2
v_o/10^{-6} M min^{-1}	1.2	3.1	6.3	9.1

i. Show that the above data obeys the Michaelis- Menten kinetics (5 marks)

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

iii. Calculate the Michaelis constant (K_M) for the reaction (2 marks)

iv. Explain the significance of Michaelis constant (K_M) (2 marks)

QUESTION THREE (20 MARKS)

a) Explain the use of the following methods in the determination of the order of a chemical reaction

i. Isolation method (3 marks)

ii. Integral method (3 marks)

b) i Differentiate between a third order reaction and a chain reaction (2 marks)

ii Explain the essential features of a chain reaction using the photochemical reaction between hydrogen and halogens (bromine, chlorine and iodine). (12 marks)

QUESTION FOUR (20 MARKS)

a) Explain how the following factors affect the reaction rate of a chemical reaction

i. Nature of reactants (2 marks)

ii. Concentration of reactants (2 marks)

iii. Temperature (2 marks)

iv. Catalyst (2 marks)

b) An explosion occurs when a reaction rate accelerates out of control:

i. Explain the mechanism of explosions (3 marks)

ii. Explain the factors that affect the explosion limits of chain reactions (6 marks)

c) Explain the Lindemann-Hinshelwood Mechanism (3 marks)

QUESTION FIVE (20 MARKS)

a) Using relevant equations, explain the following reactions:

i. Simultaneous reactions (2 marks)

ii. Consecutive reactions (2 marks)

iii. Parallel reactions (2 marks)

b) 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, $t_{1/2,}$ of the reaction 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)

c) Derive the kinetic equation of a second order reaction, in a single substance and show that the half-life ($t_{1/2}$) is a function of the initial concentration (6 marks)