MACHAKOS UNIVERSITY

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

SCH 305: CHEMICAL KINETICS

DATE: TIME:

INSTRUCTIONS:

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

Useful information

- Gas constant, R = 8.314 $JK^{-1}mol^{-1}$ (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) Elementary reactions [1 mark]

ii) Molecularity of a reaction [1 mark]

iii) Order of a reaction [1 mark]

iv) Rate law of a reaction [1 mark]

v) Activation energy [1 mark]

b) Explain **three** factors that increase the reaction rate of a chemical reaction [3 marks]

c) Ethyl iodide (C_2H_5I) decomposes at a certain temperature in the gas phase as follows: $C_2H_5I_{(g)} \rightarrow C_2H_{4(g)} + HI_{(g)}$. The following data was obtained.

Time (min)	0	15	30	48	75
$[C_2H_5I]$ (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]

d) i) The second-order rate constant for the decomposition of nitrous oxide to nitrogen molecules and oxygen atoms has been determined at various temperatures:

T (ºC)	600	650	700	750
k (M^{-1} s^{-1})	0.00187	0.0113	0.0569	0.244

Determine graphically, the value of the activation energy of the reaction [4 marks]

ii) The rate constant of a first order reaction was found to be 10 s^{-1} at 300 °C. If the activation energy is 83 kJ/mol, calculate the temperature at which its rate constant is 2.1×10^{-2} s^{-1} [4 marks]

e) The following data was collected for the reaction between hydrogen and nitric oxide at 700 °C. $2H_{2(g)} + 2NO_{(g)} \rightarrow 2H_2O_{(g)} + N_{2(g)}$

Exp.	$[H_2]$ (M)	[NO] (M)	Initial Rate (M/s)
1	0.10	0.010	1.2×10^{-3}
2	0.10	0.040	4.8×10^{-3}
3	0.20	0.010	2.4×10^{-3}

Determine the:

i) Rate law for the reaction [4 marks]

ii) Overall order of the reaction [1 mark]

iii)Rate constant [2 marks]

Section B

Answer any two questions

Q2. a) 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. [5 marks]

iii) The half life of a first order reaction is 24 days, calculate the rate constant for the reaction [3 marks]

b) Show that for a first order reaction kinetics; $[A] = [A]_0e^{-kt}$ [5 marks]

c) Iodine atoms combine to form molecular iodine in the gas phase:

$$I_{(g)} + I_{(g)} \rightarrow I_{2(g)}$$

The reaction is second order and has a rate constant of 7.0×10^9 M/s at 23 °C;

i) If the initial concentration of I is 0.086 M, calculate the concentration after 2 min [3 marks]

ii) Calculate the half-life of the reaction when the initial concentration of I is 0.6 M [3 marks]

Q3: a) Explain the use of the differential method in determination of the order of a chemical reaction [6 marks]

b) 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]

c). Explain the steady state approximation concept [5 marks]

Q4. a) i) Define the term catalyst [1 mark]

ii) Explain the effect of a catalyst on the rate of a chemical reaction. [3 marks]

iii) Describe three types of catalysis and explain their role in chemical reactions [8 marks]

b) 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]

Q5. 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]

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

$$\text{Step 1: } NO_2 + NO_2 \xrightarrow{k1} NO + NO_3$$

$$\text{Step 2: } NO_3 + CO \xrightarrow{k2} NO_2 + CO_2$$

Experimentally the rate law is 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 [2 marks]

c) 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]