

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

Section A - Compulsory.

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 ($\text{C}_2\text{H}_5\text{I}$) decomposes at a certain temperature in the gas phase as follows:

$\text{C}_2\text{H}_5\text{I}_{(\text{g})} \rightarrow \text{C}_2\text{H}_{4(\text{g})} + \text{HI}_{(\text{g})}$. The following data was obtained.

Time (min)	0	15	30	48	75
$[\text{C}_2\text{H}_5\text{I}]$ (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 (°C)	600	650	700	750
k ($\text{M}^{-1} \text{s}^{-1}$)	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 $2.1 \times 10^{-2} \text{ s}^{-1}$ [4 marks]

e) The following data was collected for the reaction between hydrogen and nitric oxide at 700°C . $2\text{H}_{2(\text{g})} + 2\text{NO}_{(\text{g})} \rightarrow 2\text{H}_2\text{O}_{(\text{g})} + \text{N}_{2(\text{g})}$

Exp.	$[\text{H}_2]$ (M)	$[\text{NO}]$ (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}

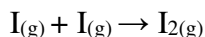
Determine the:

- 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; $[A] = [A]_0 e^{-kt}$ [5 marks]
- c) Iodine atoms combine to form molecular iodine in the gas phase:



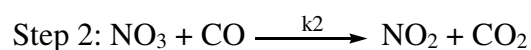
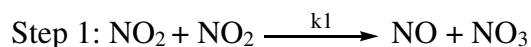
The reaction is second order and has a rate constant of 7.0×10^9 M/s at 23 °C;

- 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 enzyme-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:



Experimentally the rate law is found to be $\text{rate} = k[\text{NO}_2]^2$

- 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:

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

such that A_0 is the initial molar concentration of substance A . [8 marks]