# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

**P.O. Box 972-60200 – Meru-Kenya**
**Tel: +254(0) 799 529 958, +254(0) 799 529 959, + 254 (0) 712 524 293,**
**Website: info@must.ac.ke Email: info@must.ac.ke**


**University Examinations 2023/2024**

THIRD YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN EDUCATION SCIENCE AND BACHELOR OF SCIENCE CHEMISTRY

**SCH 3354: CHEMICAL KINETICS**

**DATE: APRIL 2024** **TIME: 2 HOURS**

**INSTRUCTIONS:** *Answer question **one** and any other **two** questions*

## QUESTION ONE (30 MARKS)

a) Define molecularity of a reaction and explain unimolecular and bimolecular reaction (4 marks)

b) Define a reaction mechanism (2 marks)

c) Using the decomposition of dinitrogen pentoxide at 50°C, define a reaction rate and state the formular that describes a reaction quantitatively. (4 marks)

(d) Consider the following reactions. Assuming the species involved take part determining the rate of reactions. For each reaction state the law and write the relevant formular.

(i) $O_3(g) \rightarrow O_2(g) + O(g)$ (3 marks)

(ii) $CH_3Br(aq) + OH^-(aq) \rightarrow Br^-(aq) + CH_3OH(aq)$ (3 marks)

(iii) $A + A + B \rightarrow$ Products (3 marks)

(e) Describe the distinction among a homogeneous, heterogeneous catalyst and an enzyme (6 marks)

(f) Discuss the importance and application of chemical kinetics (5 marks)

## QUESTION TWO (20 MARKS)

(a) Describe the following terms

(i) collision theory in relation to why reaction rates depend on temperature (2 marks)

(ii) activation energy (2 marks)

(iii) Transition state (2 marks)

(b) State and describe three laboratory methods you can use to determine the initial rate of a reaction (9 marks)

(c) Write the Arrhenius equation and define all the terms in it (5 marks)

**QUESTION THREE (20 MARKS)**

(a) The following two-step mechanism has been proposed for the gas-phase decomposition of nitrous oxide ($N_2O$):

*Step 1.* $N_2O(g) \longrightarrow N_2(g) + O(g)$

*Step 2.* $N_2O(g) + O(g) \longrightarrow N_2(g) + O_2(g)$

(i) Write the chemical equation for the overall reaction. (4 marks)

(ii) Identify any reaction intermediates. (2 marks)

(iii) What is the molecularity of each of the elementary reactions? (2 marks)

(iv) What is the molecularity of the overall reaction? (2 marks)

(b) The experimental rate law for the decomposition of ozone is second order in ozone and inverse first order in molecular oxygen: (10 marks)

$$2\,O_3(g) \longrightarrow 3\,O_2(g) \qquad \text{Rate} = -\frac{\Delta[O_3]}{\Delta t} = k\frac{[O_3]^2}{[O_2]}$$

Show that the following mechanism is consistent with the experimental rate law, and relate the observed rate constant to the rate constants for the elementary reactions:

$$O_3(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} O_2(g) + O(g) \quad \text{Fast, reversible}$$

$$O(g) + O_3(g) \xrightarrow{k_2} 2\,O_2(g) \quad \text{Slow, rate-determining}$$

$$2\,O_3(g) \longrightarrow 3\,O_2(g) \quad \text{Overall reaction}$$

**QUESTION FOUR (20 MARKS)**

Rate constants for the gas-phase decomposition of hydrogen iodide, $H_2(g) + I_2(g)$, are listed in the following table:

| Temperature (°C) | $k$ ($M^{-1} s^{-1}$) | Temperature (°C) | $k$ ($M^{-1} s^{-1}$) |
|---|---|---|---|
| 283 | $3.52 \times 10^{-7}$ | 427 | $1.16 \times 10^{-3}$ |
| 356 | $3.02 \times 10^{-5}$ | 508 | $3.95 \times 10^{-2}$ |
| 393 | $2.19 \times 10^{-4}$ | | |

(a) Find the activation energy (in kJ/mol) using all five data points. You must plot the appropriate graph on the graph paper provided. (10 marks)

(b) Calculate $E_a$ from the rate constants at 283 °C and 508 °C. (5 marks)

(c) Given the rate constant at 283 °C and the value of $E_a$ obtained in part (ii), what is the rate constant at 293 °C? (5 marks)