KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.SC. (CHEMISTRY)

COURSE CODE: **SCH 224**

COURSE TITLE: **CHEMICAL KINETICS**

DATE: 12/05/2022 **TIME: 2:00PM-4:00PM**

INSTRUCTIONS TO CANDIDATES:

TIME: 2 Hours

Answer **question ONE** and **any TWO** of the remaining

Gas constant(R) = (8.314j/mol/k)

Question One (30 marks)

(a) Define the following terms as used in this course

i. Order of reaction **(1Marks)**

ii. Rate of reaction **(1Marks)**

iii. Elementary reaction **(1Marks)**

iv. Complex reaction **(1Marks)**

(b) Let us consider a second order reaction of the type

	2A	⟶	Products
Initial conc	a		0
Final conc.	$a-x$		x

Show that its integrated rate law is given by $k = \frac{1}{at} \cdot \frac{x}{a(a-x)}$ **(5 marks)**

(c) State any three postulates of collision theory **(3marks)**

(d) State the four assumptions of collision theory **(4 marks)**

(e) The decomposition of H_2O_2 in the presence of Pt as catalyst is a first order reaction.

$H_2O_2 \xrightarrow{Pt} H_2O + O$

The progress of the reaction is followed by titrating equal volumes of the reaction mixture against standard $KMnO_4$ solution at different time intervals. A solution of H_2O_2 when titrated against $KMnO_4$ solution at different time intervals gave the following results:

t (minutes)	0	10	20
Vol $KMnO_4$(ml) used for 10 ml H_2SO_4	23.8	14.7	9.1

Show that the decomposition of H_2O_2 is a first order reaction **(4 marks)**

(f) i) Define homogeneous catalysis **(1 mark)**

(ii) Give any one example of homogeneous catalysis **(2 marks)**

(g) State the four common characteristics of catalytic reactions **(4 marks)**

(h) State the three types of elementary reactions **(3 marks)**

Question Two (20 marks)

(a) The decomposition of carbon dioxide, CO_2, to carbon monoxide, CO, and Oxygen is first order with k = 1.4 x 10^{-5} s^{-1} at 500°C.

$CO_2 \rightarrow CO + O$

What is the half-life of this reaction at 500°C? **(4 marks)**

(b) Consider a three-step reaction mechanism suggested below and use it to answer the questions that follows;

Step 1: $NO_{(g)} + NO_{(g)} \rightarrow N_2O_{2\,(g)}$ fast

Step 2: $N_2O_{2\,(g)} + H_{2\,(g)} \rightarrow H_2O_{(l)} + N_2O_{(g)}$ slow

Step 3: $N_2O_{(g)} + H_{2\,(g)} \rightarrow N_{2\,(g)} + H_2O_{(l)}$ fast

(i) Derive the overall reaction **(2 marks).**

ii) Identifying the reaction intermediate **(1 mark)**

iii) Define the term reaction intermediate **(2 marks)**

iv) Identify the rate determining step **(2 marks)**

v) Derive the rate law of the above reaction **(1 mark)**

(c) The gas-phase reaction between methane (CH_4) and diatomic sulphur (S_2) is given by the equation

$CH_4\ (g) + 2S_2\ (g) \longrightarrow CS_2\ (g) + 2H_2S\ (g)$

At 550°C the rate constant for this reaction is 1.1 $l\ mol^{-1}$ sec and at 625°C the rate constant is 6.4 $l\ mol^{-1}$ sec. Calculate E_a for this reaction **(8 marks)**

Question Three (20 marks)

(a) Determine the rate law and evaluate the rate constant for the following reaction:

$2NO_{(g)} + Br_{2\ (g)} \rightleftharpoons 2NOBr_{(g)}$

Experiment	$(NO)_o$ (M)	$(Br_2)_o$ (M)	Initial Rate of Reaction (M/min)
1	0.10	0.10	1.30×10^{-3}
2	0.20	0.10	5.20×10^{-3}
3	0.20	0.30	1.56×10^{-2}

(i) Determine the order of the reaction with respect to NO and with respect to Br_2 **(4 marks)**

(ii) Calculate the rate constant and give its units **(2 marks)**

(iii) Write the rate law for this reaction **(2 mark)**

(b) i)Using Arrhenius equation $K = Ae^{-E_a/RT}$ show that $Lnk = \frac{-E_a}{R}\left(\frac{1}{T}\right) + \ln A$ **(3 marks)**

(ii) The values of the rate constant (k) for the reaction $2N_2O_5\ (g) \longrightarrow 4NO_2\ (g) + O_2\ (g)$ were determined at several temperatures. A plot of ln k *versus* $1/T$ gave a straight line of which the slope was found to be -1.5×10^3 K. What is the activation energy of the reaction? **(3 marks)**

(c) Write down chemical equations of any three third order reactions **(3marks)**

(d) State the three types of elementary reactions **(3 marks)**

Question four (20 marks)

(a)(i) Show that the order of reaction (n) is given by $n = 1 + \frac{log\left[{}^{t_1}/_{t_2}\right]}{log\left[{}^{A_2}/_{A_1}\right]}$ using half-life method **(5 marks)**

(ii) In the reduction of nitric oxide, 50% of reaction was completed in 108 seconds when initial pressure was 336 mm Hg and in 147 seconds initial pressure was 288 mm Hg. Find the order of the reaction **(5 marks).**

(b) Describe the Michaelis-Menten mechanism **(10 marks)**

Question five (20 marks)

(a) Compound A decomposes to form B and C the reaction is first order. At 25°C the rate constant for the reaction is 0.450 s^{-1}. What is the half-life of A at 25°C? **(3 marks)**

(b) State the three types of complex reactions **(3 marks)**

(c) (i) Define the term catalyst **(1 mark).**

ii) State the three examples of heterogeneous catalysis **(3 marks)**

(d) Describe the Differential method of determining order of reaction **(10 marks)**