MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations for 2015/2016 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST SEMESTER EXAMINATION FOR DEGREE IN BACHELOR OF EDUCATION (SCIENCE)

SCH 305: CHEMICAL KINETICS

DATE: 1/8/2016 **TIME: 8:30 – 10:30 AM**

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 ℃ = 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) 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)

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 x 10^{-2} s^{-1} (4 marks)

e) Explain **three** factors that increase the reaction rate of a chemical reaction (3 marks)

SECTION B

ANSWER ANY TWO QUESTIONS

2. 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)

3. 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:

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

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)

4. 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)

5. 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)