

# 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

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

**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) 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.	[H <sub>2</sub> ] (M)	[NO] (M)	Initial Rate (M/s)
1	0.10	0.010	$1.2 \times 10^{-3}$
2	0.10	0.040	$4.8 \times 10^{-3}$
3	0.20	0.010	$2.4 \times 10^{-3}$

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<sub>2</sub>H<sub>5</sub>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
[C <sub>2</sub> H <sub>5</sub> 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 (M <sup>-1</sup> s <sup>-1</sup> )	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  $10 \text{ s}^{-1}$  at  $300 \text{ }^\circ\text{C}$ .  
If the activation energy is  $83 \text{ kJ/mol}$ , calculate the temperature at which its  
rate constant is  $2.1 \times 10^{-2} \text{ s}^{-1}$  (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 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)

3. a) Explain the meaning of the following:

i) Simultaneous reactions (1 mark)

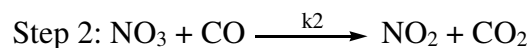
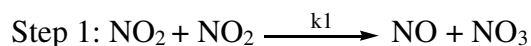
ii) Complex reactions (1 mark)

iii) Consecutive reaction (1 mark)

iv) Parallel reactions (1 mark)

v) Unimolecular reactions (1 mark)

b) The reaction between  $\text{NO}_2$  and  $\text{CO}$  to produce  $\text{NO}$  and  $\text{CO}_2$  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:  

$$-\frac{d[A]}{dt} = k[A]^n$$
 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;  $[A] = [A]_0 e^{-kt}$  (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  $7.0 \times 10^9$  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)