



# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

PHYSICAL CHEMISTRY II

SCH 2204

Second Semester Examination Paper

May 2016

This examination paper consists of 4 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Examiner's Name: Dr. S. Majoni**

## INSTRUCTIONS

1. Answer ALL questions in section A and any three (3) questions in section B
2. Each question in section A carries 10 marks and in section B carries 20 marks

## MARK ALLOCATION

QUESTION	MARKS
A1.	10
A2.	10
A3.	10
A4.	10
B1	20
B2	20
B3	20
B4	20
<b>TOTAL POSSIBLE MARKS</b>	<b>100</b>

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## SECTION A

- 1) The following data were collected for the rate of disappearance of NO and O<sub>2</sub> in the reaction:  $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$

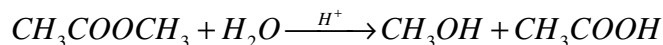
Exp. No	[NO] molL <sup>-1</sup>	[O <sub>2</sub> ] molL <sup>-1</sup>	Initial rate (molL <sup>-1</sup> s <sup>-1</sup> )
1	0.0126	0.125	1.41 x 10 <sup>-2</sup>
2	0.0252	0.250	1.13 x 10 <sup>-1</sup>
3	0.0252	0.125	5.64 x 10 <sup>-2</sup>

Determine the rate law for the reaction. [10 marks]

- 2) a) By means of an example, explain what is meant by the term reaction intermediate.

[3 marks]

- b) Methyl acetate is hydrolyzed in solution according to the following equation



Given that the rate constant for the reaction at 25<sup>o</sup>C is 1.26 × 10<sup>-4</sup> s<sup>-1</sup>

- i) What is the order of the reaction. [1 mark]
- ii) What is the half-life of the reaction and how long will it take for 65% of the methyl acetate to react? [6 marks]
- 3) a) The concentration of NaCl in a solution that also contains Cu(NO<sub>3</sub>)<sub>2</sub> is 0.0083 m, if the ionic strength of the solution is 0.015m, what are the concentrations of copper and nitrate ions? [5 marks]
- b) If a reaction has a rate constant of 2.40 × 10<sup>-3</sup> sec<sup>-1</sup> at 273 K and 2.65 × 10<sup>-3</sup> sec<sup>-1</sup> at 298 K, what is the activation energy of the reaction? [5 marks]

- 4) a) With the aid of examples, explain the difference between a weak and a strong electrolyte. [4 marks]

- b) A standard solution of KCl with a conductivity of 1.063 × 10<sup>-6</sup> Sm<sup>-1</sup> at 298 K was used to calibrate a conductivity cell and a resistance of 4.22 Ω was measured. The same cell was filled with a solution of HCl, and a resistance of 1.033 Ω was measured. Calculate the conductivity of the HCl solution. [6 marks]

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### SECTION B

- 1) The data below shows the molar conductivities of sodium acetate as a function of concentration in aqueous solution at 298 K. From the data, is sodium acetate a strong or weak electrolyte and what is the value of  $\Lambda_m^\circ$ ? [20 marks]

Concentration (M)	$\Lambda_m$ (S m <sup>2</sup> mol <sup>-1</sup> )
0.0005	0.00892
0.001	0.00885
0.005	0.00857
0.01	0.00838
0.02	0.00812
0.05	0.00769

- 2) The composition of a liquid-phase reaction,  $2A \rightarrow B$ , was followed by a spectrophotometric method with the following results.

$t$ (min)	$[B]$ (mol/L)
0	0
10	0.089
20	0.153
30	0.200
40	0.230

- a) What are the conditions required for a reaction to be monitored by spectrophotometric methods. [2 marks]
- b) Determine the order of the reaction and the rate constant, thus write the rate law in the form of  $rate = k[A]^n$ . [18 marks]
- 3) a) Discuss the importance of the wave particle duality in quantum chemistry [4 marks]
- b) What do you understand by the term quantization of energy? Explain how the principle of quantization of energy forms the basis of spectrometry. [4 marks]
- c) For the electrochemical cell represented as:



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(i) Write down the half-cell reactions in the cell above. [3 marks]

(ii) How does the value of the cell potential vary as HCl concentration is varied from 0.01 *m*, to 0.001 *m*, to 0.01 *m*? [9 marks]

4) Enzyme catalyzed reactions can be represented as  $E + S \xrightleftharpoons[k_{-1}]{k_1} ES \xrightarrow{k_2} P + E$

d) An enzyme is a homogenous catalyst. Explain what is a homogeneous catalyst and, using a potential energy diagram, describe how a catalyst increases the rate of a chemical reaction. [6 marks]

e) Identify intermediate(s) and the catalyst in the above equation and, using steady

state approximation, show that the rate equation,  $\text{rate} = \left( \frac{k_2 k_1 [S][E]}{k_{-1} + k_2} \right)$  can be

obtained by using either the reactant or the product. [14 marks]