MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: PHYSICAL CHEMISTRY FOR ENGINEERS

CODE: ENGT 104

SESSIONAL EXAMINATIONS
NOVEMBER 2022

DURATION: 3 HOURS

EXAMINER: MR M. MAPOSA

INSTRUCTIONS

1. *Answer **All** Questions*
2. *All questions carry equal number of marks*
3. *Start a new question on a fresh page*
4. *Total marks 100*

Additional material(s): *Data booklet/ Graph page*

QUESTION 1

In this question you can use the following constants:

Planck's Constant = 6.63 x10^{-34} Js, Electron mass = 9.11 x 10^{-31} kg, 1 eV = 1.602 x 10^{-19} J, speed of light = 3 x 10^{8} m/S

a) Explain the following observations made during a photoelectric investigation

(i) electrons ejected from the same metal surface during photoelectric emission have different kinetic energies

(ii) the intensity of light incident on a metal surface increases the number of ejected electrons

(iii) frequency of the incident light increases the kinetic energy of the ejected electrons

(iv) only light of a certain minimum frequency can result in photoelectric emission

(v) different metals have different work functions [12]

b) De Broglie is one of the scientists who contributed significantly to the idea of wave particle duality. He made it possible to calculate the wavelength of any moving object.

i) Give the De Broglie expression which relates wave length to plank's constant, mass and velocity of a moving object.

ii) Calculate the de Broglie wavelength of

1 a lorry of mass 3500 kg traveling at a speed of 30 m/s

2 An electron travelling at a speed of 100 m/s

iii) Explain fully why the wavelength of the lorry is insignificant to consider

iv) At what velocity would an iron ball of mass 6.5 kg move so as to have the same wavelength as an electron travelling at 100 m/s [13]

QUESTION 2

a) Draw a schematic diagram to show the components of a single beam UV-VIS spectrometer [4]

b) State any two strengths and one limitation of UV-VIS spectroscopy [4]

c) Beer's law can be used to evaluate concentration from absorbance of an analyte.

i) State Beer's law and highlight the significance of each term

ii) The calibration curve used to analyse the concentration of a pollutant in the effluent had a line of best fit represented by the equation; **y = 0.998x + 0.01.** Calculate the concentration of the pollutant in an effluent sample which gave an absorbance reading of 0.06.

iii) In another different experiment, phenol concentration was analysed using UV-VIS. A sample of concentration 0.05 $moldm^{-3}$ gave an absorbance value of 412 using cells of pathlength one centimeter. Deduce a value for the molar absorptivity (**Ɛ**) with correct units.

[9]

d) CO_2 is an inactive molecule.

i) Explain fully the meaning of this statement

ii) Calculate the degrees of freedom for the vibrations of the following molecules 1. CO_2

2. SO_2

3 CH_3CH_3 [9]

QUESTION 3

(a) With the aid of examples distinguish between unimolecular and bimolecular elementary steps of a reaction mechanism. Show clearly how such steps are related to the rate law of a reaction. [6]

(b) The following data was collected from a series of experiments carried out on the reaction: **2A→B+C**

Rate/mol/ dm^3s^{-1}	0.0010	0.0019	0.0039	0.0081	0.0159	0.0318
Conc of A (mol/dm^3)	0.025	0.050	0.100	0.200	0.400	0.800

i) Plot a graph of rate of reaction against concentration of A

ii) Deduce the order of reaction with respect to the concentration of A and the rate equation

iii) Use your graph to find the rate constant of the reaction

iv) Determine the half-life of the reaction

v) Predict the rate of reaction when the concentration of A was lowered to $0.001 moldm^{-3}$ [12]

(c) Give the Arrhenius equation in natural log form stating the units of each term in the equation [3]

(d) The rate constant for the decomposition of compound **A** was determined at two different temperatures; **2A→B+C.** At 600 K $k_1 = 1.95 \times 10^{-7}\ dm^3\ mol^{-1}s^{-}$. At 700 K $k_2 = 2.01 \times 10^{-6}\ dm^3mol^{-1}s^{-1}$. Determine the value of the activation energy of the reaction [4]

QUESTION 4

a) Write a brief summary on each of the following

i) Collision theory

ii) Lindeman theory

iii) Steady state approximation

[9]

b) The following mechanism describes a reaction in which an inorganic substance X_2Y_5 decomposes to form Y_2, and XY_2

$$X_2Y_5 \underset{k_b}{\overset{k_f}{\rightleftarrows}} XY_2 + XY_3 \quad XY_2 + XY_3 \xrightarrow{k_2} XY_2 + XY + Y_2 \quad XY_3 + XY \xrightarrow{k_3} 2XY_2$$

Use steady state approximation to deduce the expression for the

i) Steady state concentration of the intermediate *XY*

ii) Steady state concentration of the intermediate XY_3

iii) Rate of the overall reaction in terms of change in concentration of X_2Y_5

iv) Overall rate constant **K** in terms of k_f, k_b k_2 and k_b

v) Deduce the overall rate constant **K,** when k_b is many times smaller than k_2

vi) Deduce the overall rate constant **K**, when k_b is many times greater than k_2 [16]

END OF EXAMINATION