



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 = 6.63×10^{-34} Js, Electron mass = 9.11×10^{-31} kg, $1 \text{ eV} = 1.602 \times 10^{-19}$ J, speed of light = 3×10^8 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.
- State Beer's law and highlight the significance of each term
 - 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.
 - In another different experiment, phenol concentration was analysed using UV-VIS. A sample of concentration 0.05 mol dm^{-3} gave an absorbance value of 412 using cells of pathlength one centimeter. Deduce a value for the molar absorptivity (ϵ) with correct units. [9]
- d) CO_2 is an inactive molecule.
- Explain fully the meaning of this statement
 - 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: $2\text{A} \rightarrow \text{B} + \text{C}$

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 0.001mol dm^{-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; $2\text{A} \rightarrow \text{B} + \text{C}$. At 600 K $k_1 = 1.95 \times 10^{-7} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$. At 700 K $k_2 = 2.01 \times 10^{-6} \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$. Determine the value of the activation energy of the reaction [4]

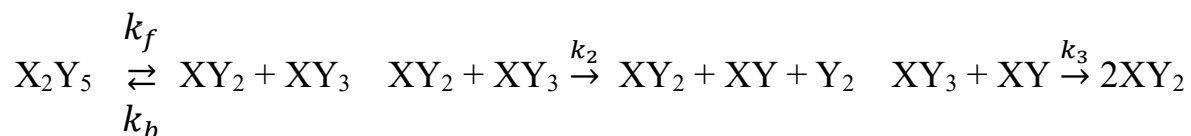
QUESTION 4

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



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_3
- 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