## MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING<br>CHEMICAL AND PROCESSING ENGINEERING<br>PHYSICAL CHEMISTRY FOR ENGINEERS/ PHYSICAL CHEMISRY<br>CODE: ENGT 104/HCHE112<br>SESSIONAL EXAMINATIONS<br>MARCH 2021

## DURATION: 3 HOURS

LECTURER: MR M MAPOSA

## INSTRUCTIONS

1. Answer all questions
2. Each question carries 25 marks
3. Total marks 100

ADDITIONAL MATERIAL
Periodic table Graph page

## QUESTION 1

(a) Define the following terms as used in quantum chemistry
(i) Photon
(ii) Work function
(iii) Quanta
(iv) Wave function
(v) Photoelectric effect
[5 marks]
(b) A photoelectric experiment showed that 5.8 eV of energy are required to remove an electron from metal X
(i) Describe any two applications of the concept of photoelectric effect
(ii) Explain why electrons ejected from the same metal surface possess different values of kinetic energy
(iii) What is the maximum wavelength of light that will eject an electron from metal X ?
(iv) If light of 200 nm wavelength were used, what is the velocity of the emitted electron?
(c) State any two observations in support of the
(i) Wave nature of radiation
(ii) Particle nature of radiation

## QUESTION 2

a) Write brief notes on each of the following terms with regard to reaction kinetics
(i) Order of reaction
(ii) Reaction rate
(iii) Arrhenius equation
(iv) Activation energy
(v) Rate constant
(vi) Mechanism of reaction
(vii) Rate determining step
(viii) Reaction intermediate
(ix) Transition state
(x) Quenching [10 marks]
(b) Table 1 shows data obtained from experiment when the decomposition of $\mathrm{N}_{2} \mathrm{O}_{5}$ was followed at 350 K . The equation of reaction is:

$$
2 \mathrm{~N}_{2} \mathrm{O}_{5} \rightarrow 4 \mathrm{NO}_{2}+\mathrm{O}_{2}
$$

## Table 1

| $\left[\mathrm{N}_{2} \mathrm{O}_{5}\right] / \mathrm{M}$ | 1.00 | 0.71 | 0.50 | 0.35 | 0.25 | 0.17 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Time $/ \mathrm{min}$ | 0 | 1 | 2 | 3 | 4 | 5 |

Deduce the order of reaction, rate equation, half-life and rate constant of the reaction
[12 marks]
b) Calculate the rate constant, for the radioactive decomposition of an isotope of uranium which has a half-life of 1570 years

## QUESTION 3

(a) State three modes of vibrations shown by molecules which are dipolar
(b) Briefly explain what is meant by ir active molecules
(c) Using $\mathrm{CO}_{2}$ and $\mathrm{SO}_{2}$ as examples, illustrate those modes of vibration [6 marks]
(d) Calculate the degrees of freedom of vibrational modes in
i. Carbon dioxide
ii. Sulphur dioxide
iii. Water
[9 marks]
e) Briefly outline any two strengths and two limitations of Raman spectroscopy when compared to other molecular spectroscopic techniques [4 marks]

## QUESTION 4

a) Write brief notes on each of the following terms:
i. Complex reaction
ii. Chain reaction
iii. Unimolecular elementary step
iv. Bimolecular elementary step
v. Steady state approximation
[10 marks]
b) Compare and contrast the Lindeman theory and the RRKm theory in the kinetics of gaseous reactions.
[5 marks]
c) In terms of internal degrees of freedom in the RRKM theory, explain adiabatic modes and active modes of reactants.
[4 marks]
d) Describe any two limitations associated with classical mechanics which necessitated the development of quantum mechanics.
e) State the first two postulates of quantum mechanics [2 marks]

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| Group |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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