MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

CHEMICAL AND PROCESSING ENGINEERING

PHYSICAL CHEMISTRY FOR ENGINEERS/ PHYSICAL CHEMISRY

CODE: ENGT 104/HCHE112

SESSIONAL EXAMINATIONS

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? [16 marks]

(c) State any **two** observations in support of the

(i) Wave nature of radiation
(ii) Particle nature of radiation [4 marks]

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 N_2O_5 was followed at 350 K. The equation of reaction is:

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

Table 1

$[N_2O_5]$/ M	1.00	0.71	0.50	0.35	0.25	0.17
Time/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 [3 marks]

QUESTION 3

(a) State **three** modes of vibrations shown by molecules which are dipolar [3 marks]

(b) Briefly explain what is meant by ir active molecules [3 marks]

(c) Using CO_2 and 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

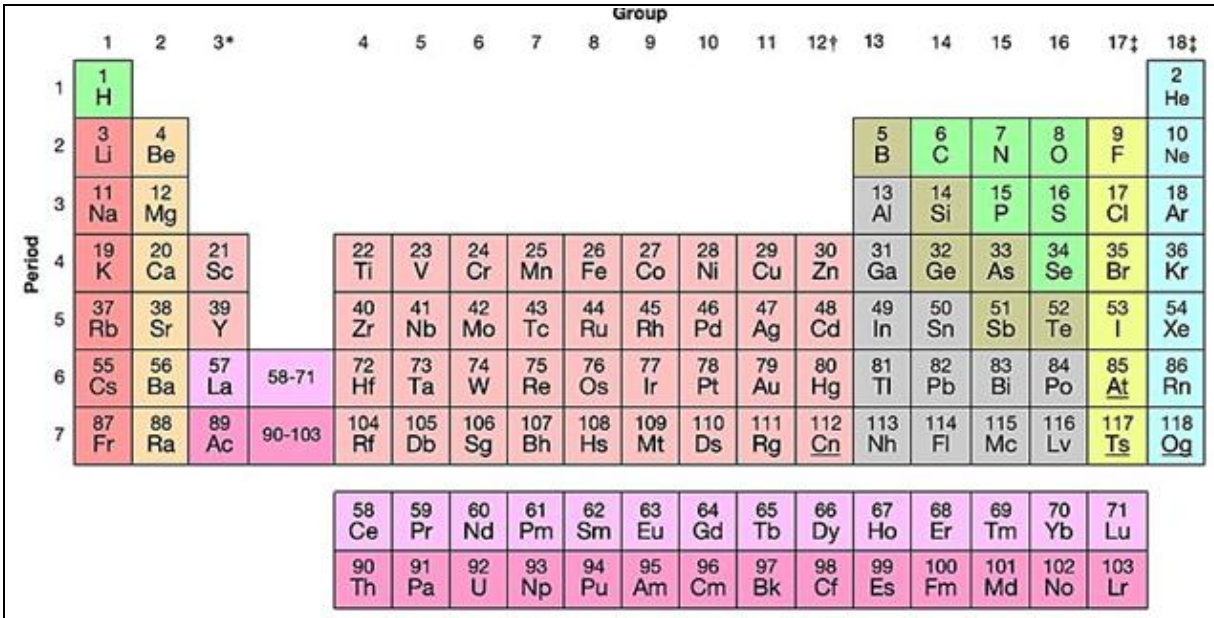
a) Write brief notes on each of the following terms:
   i. Complex reaction
   ii. Chain reaction
   iii. Unimolecular elementary step
   iv. Bimolecular elementary step
   v. Steady state approximation [10 marks]

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. [4 marks]

e) State the first two postulates of quantum mechanics [2 marks]


Group
Period
1 2 3* 4 5 6 7 8 9 10 11 12† 13 14 15 16 17‡ 18‡
1 H He
2 Li Be B C N O F Ne
3 Na Mg Al Si P S Cl Ar
4 K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
5 Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
6 Cs Ba La 58-71 Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
7 Fr Ra Ac 90-103 Rf Db Sg Bh Hs Mt Ds Rg Cn Nh Fl Mc Lv Ts Og
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

END OF PAPER