

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:

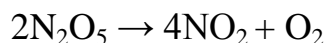


Table 1

[N ₂ O 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 CO₂ and SO₂ 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																		
		1	2	3*	4	5	6	7	8	9	10	11	12†	13	14	15	16	17‡	18‡	
Period	1	1 H																		2 He
	2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
	3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
	4	19 K	20 Ca	21 Sc		22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
	5	37 Rb	38 Sr	39 Y		40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
	6	55 Cs	56 Ba	57 La	58-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
	7	87 Fr	88 Ra	89 Ac	90-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu					
		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr					

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