CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE AND EDUCATION

CHEM 211: PHYSICAL INORGANIC CHEMISTRY

STREAMS: B.Ed (SC) (BS.c) **TIME: 2 HOURS**

DAY/DATE: FRIDAY 8/12/2017 **11.30 A.M - 1.30 A.M.**

INSTRUCTIONS:

- **Answer Question ONE and any other TWO Questions**

USEFUL DATA

Velocity of light $(C) = 3x10^8 m/s$
Metre $(m) = 10^9 nm$
Avogadro number $(N_a = 6.022x10^{23} mol^{-1})$
Planck constant $(h) = 6.626x10^{-34} J\ s$
Ryderberg constant $(R) = 1.0974X10^7 m^{-1}$

QUESTION ONE (COMPULSORY) [30 MARKS]

(a) The electromagnetic spectrum is divided up into regions which are connected with their effects on matter with which they interact. Name the various regions of the spectrum. [3 Marks]

(b) The electromagnetic radiation is in a form of energy which is particulate in nature made up of packets of energy (photons). Calculate the molar quantum energy associated with the radiation of wavelength (λ) 253.7 nm. [3 Marks]

(c) Explain briefly the phenomenon of photoelectric effect with the help of suitable equations. [3 Marks]

(d) Electromagnetic radiation is considered both a wave and a particle. Based on this statement, derive de Broglie's equation on dual nature of matter. [2 Marks]

(e) The hydrogen emission spectrum consists of a series of discrete lines. The wavelength (λ) of the lines is given by the Rydberg equation; $1/\lambda = R\left[1/n^{i}{}^{2} - 1/n^{j}{}^{2}\right]$.

(i) Define n_i and n_j. [1 Mark]

(ii) From the Rydberg equation above, derive the expression for frequency (v). [1 Mark]

(iii) Explain with suitable equations how the following lines Lyman, Balmer, Paschen, Brackett and Pfund are generated in the line emission spectrum of hydrogen. [2½ Marks]

(f) Briefly explain the Heisenberg's Uncertainty Principle. [2 Marks]

(g) The wave motion of an electron may be described by an equation of a standing wave given by: $\Psi_{(x)} = Asin2\pi x/\lambda$ where A is a constant.

(i) Show that $d^2\Psi/dx^2 = k\,\psi$ where k is constant [1½ Marks]

(ii) Determine the value of k. [½ Mark]

(iii) Given that the total energy (E) of an electron is given by $E = K.E + P.E.$, $½\,mv^2 + U$, where $U = P.E.$ and that $\lambda^2 = h^2/m^2\,m^2$, show that $\Psi_{(x)} = Asin\,2\pi/\lambda$ can be transformed to: $\frac{d^2\Psi}{dx^2} + \left(\frac{8\Pi^2 m(E-U)}{h^2}\right)\Psi = 0$. [2 Marks]

(h) The Schroedinger equation for a particle in a one-Dimensional box is given by; $\Psi_{(x)} = (2/a)^{½}$ sin $n\pi x/a$ where a is the length of the box. The energy equation for the particle in the box is given by $E_n = n^2h^2/8ma^2$

(i) Sketch curves for the functions of $\Psi_{(x)}$ and $\Psi^2{}_{(x)}$ for the particle in the box for n=1, 2, 3. [2 Marks]

(ii) Show how energy for the particle in the box varies with n. [1 Mark]

(iii) What is the physical meanings attached to $\Psi_{(x)}$ and $\Psi^2{}_{(x)}$? [1 Mark]

(i) When the Schroedinger equatin is solved for hydrogen atom, the following quantum numbers are obtained n, 1 and m.

(i) Describe what these quantum numbers represent and show the relationships existing among them. [1½ Marks]

(ii) If the value of 1 is 3m what are the permitted values of m? [1½ Marks]

(iii) State whether the following sets of quantum numbers below are valid descriptions of atomic orbitals, and explain why some are invalid. [1½ Marks]

	n	1	m
(a)	2	2	0
(b)	3	1	-1
(c)	3	1	-2

QUESTION TWO [20 MARKS]

(a) In the periodic table elements are arranged in the order of increasing atomic numbers in such a way that elements with similar properties fall in the same group. The recurrence of similar properties of the elements is called periodicity. Explain precisely how the following properties vary across and down the periodic table.

(i) Ionizable energies of the elements. [4 Marks]

(ii) Electronegativity of the elements. [4 Marks]

(b) The first electron affinity of the element is an exothermic process. Explain why the second electron affinity for an element is an endothermic process. [2 Marks]

QUESTION THREE [20 MARKS]

(a) Atoms undergo chemical bonding to form molecules through the overlap of atomic orbitals. Give there conditions as stipulated by the molecular orbital theory for there to be effective overlap of atomic orbitals to form molecular orbitals. [3 Marks]

(b) Draw a suitable labeled molecular orbital energy level diagram showing clearly how the atomic orbitals from two N atoms can overlap to form N_2 molecule. From the diagram determine the following;

(i) The electron configuration for $N_{2.}$. [3 Marks]
(ii) If N_2 is diamagnetic or paramagnetic. [1 Mark]
(iii)The bond order of $N_{2.}$ [1½ Marks]
(iv)The number of bonds in $N_{2.}$ [1½ Marks]

QUESTION FOUR [20 MARKS]

(a) Briefly explain how Valence Bond theory explains bonding in molecules, pointing out the major difference between this theory and the molecular orbital theory. [4 Marks]

(b) Using the valence bond theory, explain how the following molecules $CH_{4,}$ NH_3 and H_2O are formed using sp^3 hybridization of atomic orbitals. [4 Marks]

(c) Explain the structural (shapes) differences that exist among the three molecules in 3 (b). [2 Marks]

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