UNIVERSITY EXAMINATIONS 2013/2014 ACADEMIC YEAR

2nd YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION SCIENCE

COURSE CODE/TITLE: SCH 200: ATOMIC STRUCTURE AND BONDING.

END OF SEMESTER: I DURATION: 3 HOURS

CONSTANT: Speed of light =3.0 $\times 10^8$ m.sec, Planck's constant = 6.62 X 10^{-34} Js; mass of electron = 9.1091 X 10^{-31} kg; N_A = 6.022 x 10^{23} mol^{-1}; Rydberg constant = 2.18 X 10^{-18}J; charge of electron (e) = 1.60210 × 10^{-19} C; permittivity of vacuum (ε_0) = 8.854185 × 10^{-12} kg M^{-3}; nm = 1.0 x10^{-9} M, π = 3.14, J = kg m^2s^{-2}, 1pm = 10^{-12}m

SECTION A (40MKS): ANSWER ALL QUESTIONS

QUESTION ONE (30MKS)

a) What values are assigned to quantum number *n, l,* and *ml* for; *2S, 2p* and *4d* orbitals **(4.5mks)**

b)

(i) State Heisenberg uncertainty principle **(1mk)**

(ii) According to Bohr's theory of hydrogen – atom, the velocity of an electron in the 1st orbital is 2.183× $10^6 ms^{-1}$. If the uncertainty in the position of the electron is 5 pm, what will be the uncertainty in velocity? **(3.5mks)**

c) Calculate the wave length of an electron travelling with one-third speed of light **(3mks)**

d)

(i) Differentiate between electronegativity and electron affinity **(1mks)**

(ii) Estimate the electronegativity of **S** according to Pauling given that the bond dissociation energies ($kJmol^{-1}$) for; **S-S, S-F** and **F-F** are 264, 496 and 155 kJ/mol respectively, if the electronegativity of **F** is **4.1** **(3mks)**

e) An electron in a one – dimensional box requires a wave – length of 8080 nm to excite an electron from the *n* = 2 to *n* = 3 energy level. Calculate the length of the box in nm **(6mks)**

f) Write down a normalized wave function equation for a hydrogen atom **(1mks)**

g) Differentiate between radial node and radial probability **(2mks)**

g) Using the Slater's orbital rules,

(i) Justify why*3d* orbitals fill after the *4s*orbitals **(2.5mks)**

(ii) Defend why, it's the *ns* electrons removed and not the ***(n-1)d*** electrons which are removed first when Mn, (Z = 25), is converted to Mn^{2+} ion. **(2.5mks)**

h) State two property of an eigen acceptable wave function **(1mks)**

QUESTION TWO (10MKS)

(a) Write a note on physical significance for each of the below terms, as used in explaining Schrodinger wave equation

(i) Ψ **(1mk)**

(ii) Ψ^2 **(1mk)**

(b) The wave function (z – direction) of a particle in a box is given by; $\Psi_z = B \sin(n\pi z/L)$, where B and L represents a number and length respectively. Using this equation and the Schrodinger equation show that: $E = n^2 h^2 / 8mL^2$ **(4mks)**

c)

(i) State one similarity between a Lewis base and a ligand **(1mk)**

(ii) Using valence bond theory explain why the complex $[Co(NH_3)_6Cl_3]$ is paramagnetic, hence calculate the Bohr Magneton (BM) value for the complex.

(Co, Z = 27) **(3mks)**

SECTION B: ANSWER ANY THREE QUESTIONS (30MKS)

QUESTION THREE (15MKS)

a) Differentiate between paramagnetic and diamagnetic substances? **(2mks)**

b) Calculate the magnetic moments (μ) of $[Cr(NH_3)_6]Cl_3$ **(2mks)**

c) Deduce the number of unpaired electrons in $[Cu(NH_3)_4]Br_2$ with a μ 0f 1.71BM **(4mks)**

d) Determine the effective Nuclear Charge (Z_{eff}) at the periphery of **N** atom if, **Z=7**, using the Slater orbital approximation **(2mks)**

e) (i) Using a mathematical expression, explain what is meant by the term a quantum. **(2mks)**

(ii) Chlorophyll a is green because it absorbs blue and red light at about 435nm and 680nm respectively, so that mostly green light is transmitted. Calculate the energy per mole of the photon at wavelength 680nm. **(3mks)**

QUESTION FOUR (13MKS)

a) Define the term hybridization **(1mk)**

b) Draw the Lewis structure and predict the type of hybridization as well as suggesting the molecular shape for the following molecular formulas

i. XeF_4 **(2mks)**

ii. I_3^- **(2mks)**

c) Using molecular orbital theory explain why the complex $\mathbf{[Co(NH_3)_6]^{3+}}$ is diamagnetic. **(6.5mks)**

c) State three assumptions based on Bohr's hydrogen atomic model theory **(1.5mks)**

d) Calculate the Bohr's radius for hydrogen atom, when *n* = 2 **(3mks)**

QUESTION FIVE (15MKS)

(a) Explain using examples the difference between atomic orbital and a shell **(2mks)**

(b) Determine the total number of orbitals and their designation present for the principal quantum number $n = 5$ **(3mks)**

(c) Calculate the energy difference in ($Jmol^{-1}$) for an electron at an energy state 4 and 6 that is confined to a box whose length is 0.6nm **(4mks)**

d) The particle N_2^{2+} can be prepared by bombarding the N_2 molecules with fast moving electrons. Using molecular orbital diagram predict;

(i) Electronic configuration of the ion **(4mks)**

(ii) Calculate the bond order of the ion N_2^{2+} **(2mks)**