MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SCH 200: ATOMIC STRUCTURE AND BONDING

DATE: 29/4/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

Answer Question One [Compulsory] And Any Other Two Questions.

USEFUL CONSTANTS:

$\varepsilon_o = 8.854 \times 10^{-12}\ Fm^{-1}$

$No = 6.023 \times 10^{23}\ mol^{-1}$

$1\ eV = 1.602 \times 10^{-19}\ J$

h = Planck's constant $= 6.626 \times 10^{-34}\ J.s$

m = mass of electron $9.1079 \times 10^{-31}\ kg$

e = electronic charge $1.602 \times 10^{-19}\ C$

$R = 109677.8\ cm^{-1}$.

QUESTION ONE (30 MARKS)

a) Classical mechanics is one of the two major sub-fields of study in the science concerned with the set of physical laws governing and mathematically describing the motions of bodies and aggregates of bodies. A few assumptions of classical mechanics have been put in place to effectively describe dynamic variables. The other sub-field is found in quantum theories. Quantum mechanics is concerned with the set of physical laws governing end mathematically describing the motion of microscopic bodies. In the context of these statements, answer the following questions.

i. State THREE major assumptions of classical mechanics (2 marks)

ii. Before the introduction of the quantum theory, there are specific cases which defied classical mechanics. Name TWO of them. (2 marks)

iii. Describe very briefly two experiments that show the dual nature of electromagnetic radiation and at the same time confirm the reliability of Planck's quantum theory.
(3 marks)

b) Describe the characteristic atomic hydrogen emission spectrum in the visible region of the electromagnetic spectrum (3 marks)

c) Show that the permitted energies of an electron confined in a box is given by;

$E_n = \frac{n^2h^2}{8ma^2}$ (4 marks)

d) Define the following terms

i. Shielding;

ii. Van der Waals radius

iii. Lewis structure

iv. Electronegativity (4 marks)

e) By constructing a molecular orbital picture for O_2, NO and B_2 determine whether they are paramagnetic or diamagnetic (B=5, N=7, O=8). (4 marks)

f) Write down the Born-Lande equation and define all its terms. (3 marks)

g) In an ionic crystal three forces operate and determine the stability of a lattice. State them
(3 marks)

h) Calculate the effective nuclear charge on a 3d electron in a Nickel atom, given the electron configuration of Ni: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$. 2 marks

QUESTION TWO (20 MARKS)

a) Using the Schrodinger equation distinguish between what happens in a one dimensional box and a three dimensional box. Derive the relevant equations. (8 marks)

b) Plot the radial distribution function $4\pi r^2 R(r)$ for 1s, 2s and 2p orbitals of the hydrogen atom (6 marks)

c) In the context of atomic wavefunctions describe the following quantum numbers

i. Principal quantum number *n*

ii. Azimuthal quantum number *l*

iii. Magnetic quantum number *m* (6 marks)

QUESTION THREE (20 MARKS)

a) Draw the three-dimensional boundary surface diagrams of an s, p and d orbitals. In each case draw the simple 2-dimensional representation. (8 marks)

b) Using relevant examples describe sp^3 and sp^3d hybridization (6 marks)

c) Discuss hybridization and hence delocalized bonding in ethylene (C_2H_4) and in acetylene (C_2H_2) (6 marks)

QUESTION FOUR (20 MARKS)

a) Discuss Fajan's rules (6 marks)

b) Describe the periodic trends of the following atomic parameters (4 marks)

i. Effective nuclear charge,

ii. Electron affinity

c) Discuss the applications of the Radial distribution function $4\pi r^2 R(r)$ and the Radial wavefunction R(r) in describing atomic properties (10 marks)

QUESTION FIVE (20 MARKS)

a) Express the Linear Combination of Atomic Orbitals (LCAO) theory equation and describe in detail the rules and procedure used to construct molecular orbitals (10 marks)

b) Draw orbital correlation diagrams for hypothetical H-H and He-He molecules (4 marks)

c) Give an account of a detailed discussion on the nature of a chemical bond according to valence bond theory. (6 marks)